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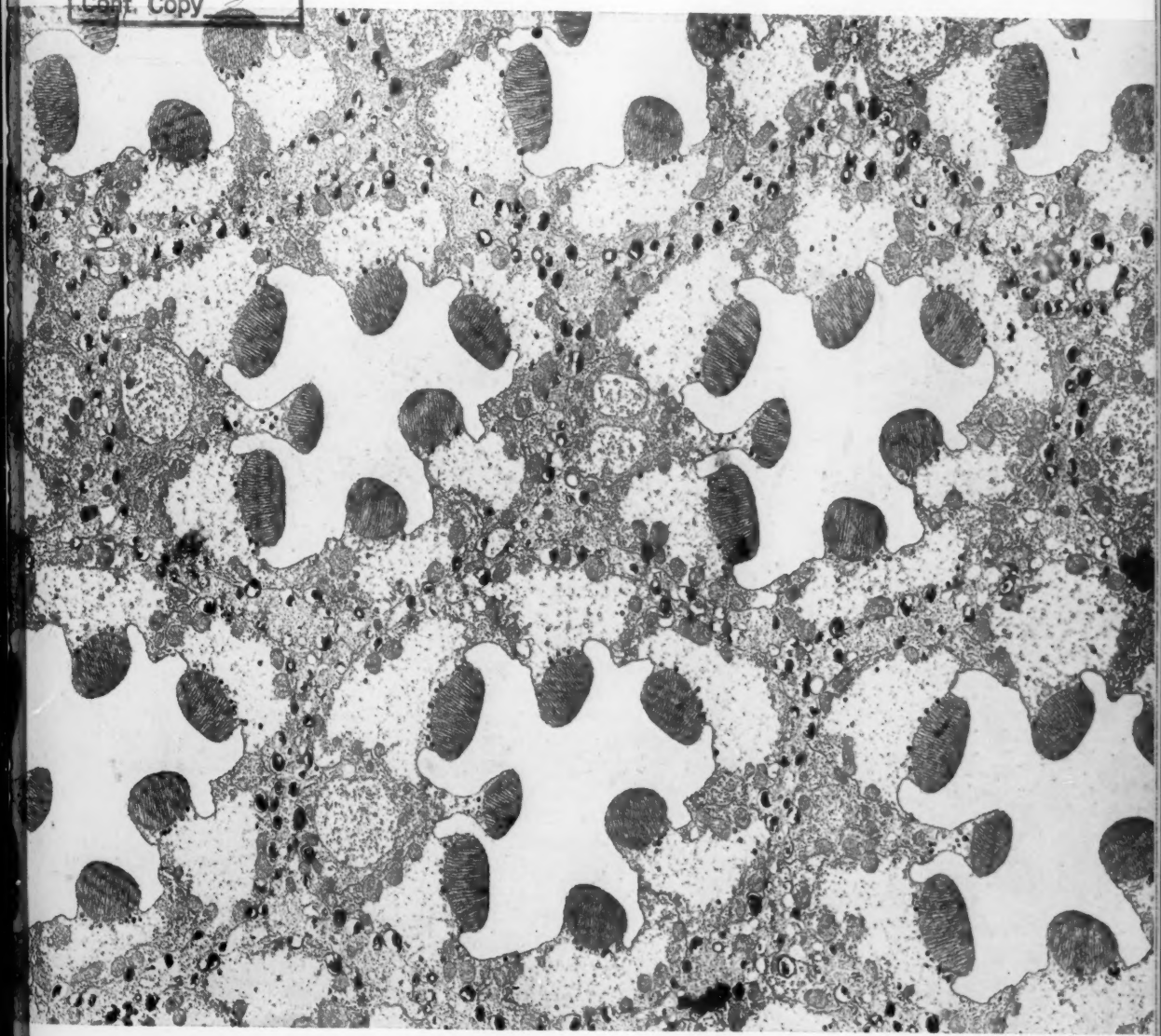

Index Issue

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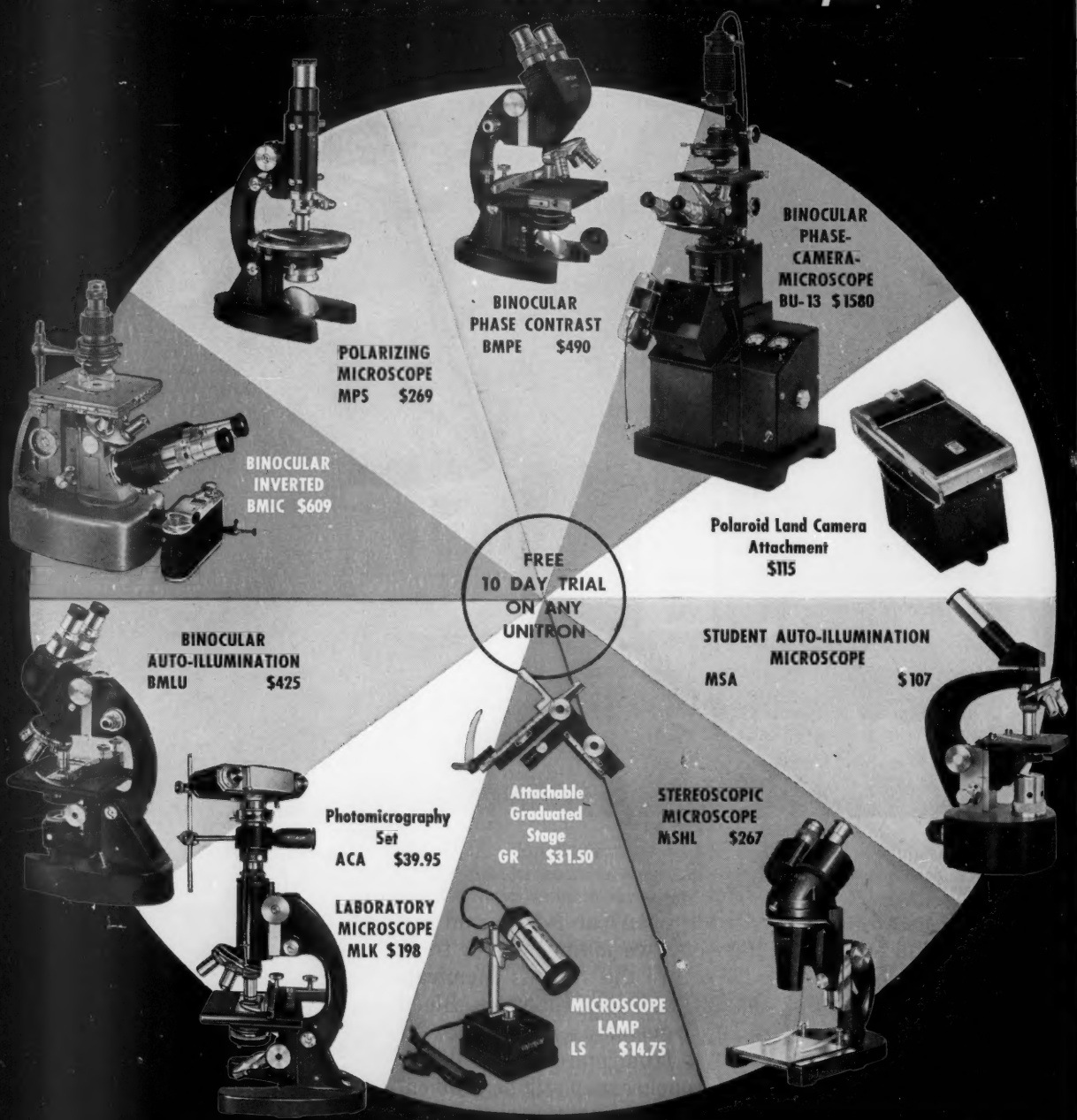
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Thin section through a group of ommatidia in the eye of *Drosophila melanogaster* at the late pupal stage. In each ommatidium are seven main retinula cells, each bearing a rhabdomere composed of a compact mass of tubules. The arrangement of the retinulae is rather precisely repeated from one ommatidium to the next (× 20,000). [C. H. Waddington, Institute of Animal Genetics, Edinburgh, Scotland]

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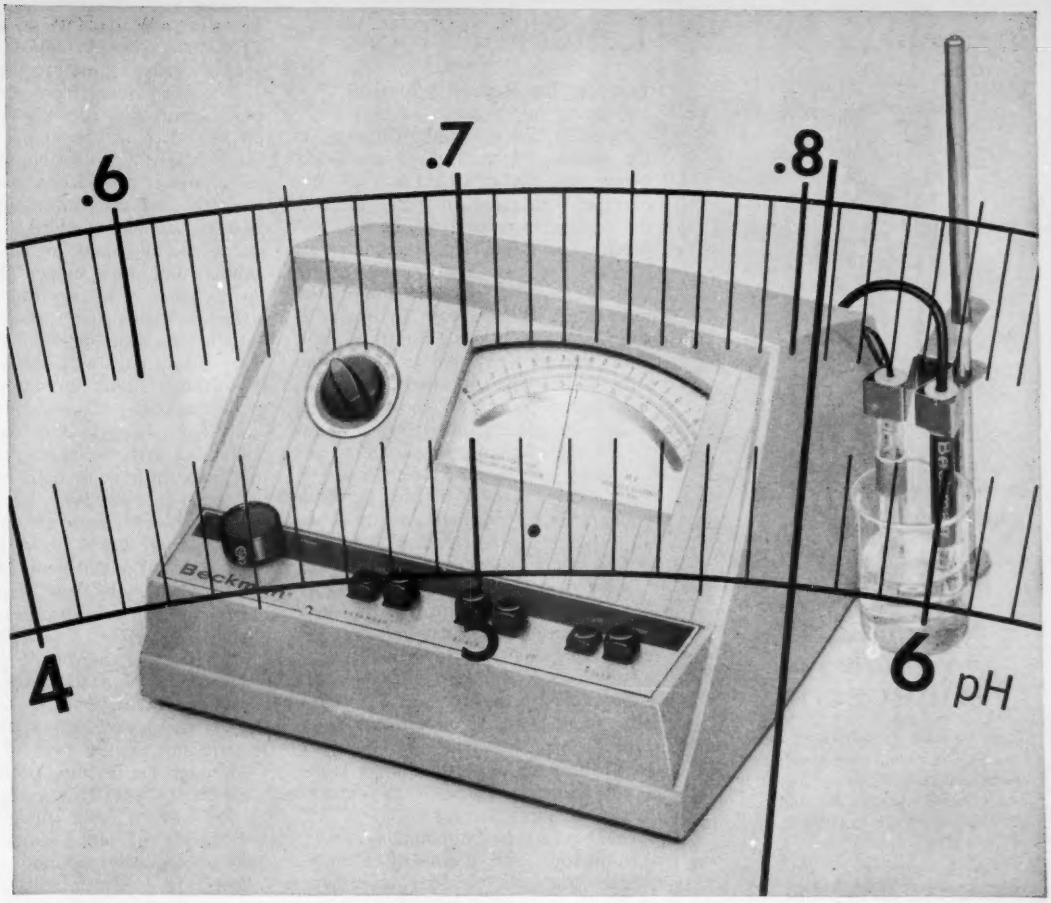

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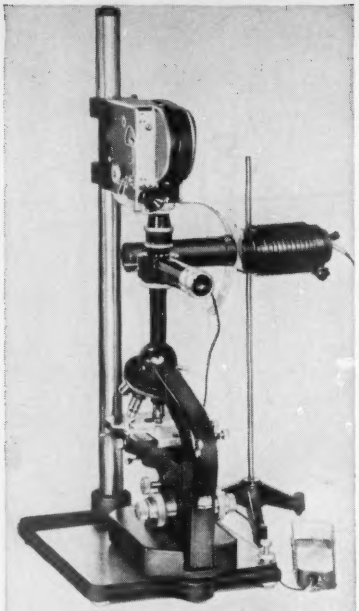

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Letters

Institute for Retired Scientists

Scientists are essentially dedicated to the seeking of truth, their chief tool being their ability to think. With the onset of retirement, in most instances, the decline in mental ability does not parallel the more rapid diminution of physical capacity. Yet this fact seems to have been overlooked in compulsory retirement policies now in force at numerous institutions. Certainly these elder citizens who have pursued truth for so long could, if properly organized, constitute a source of knowledge and wisdom as yet untapped in our quest for a more efficient utilization of a potentially great "natural" resource.

Therefore, would it not be both profitable and beneficial to create an institute for retired scientists? The following thoughts occur to me in this regard: (i) that scientists monetarily subscribe early and throughout their lives towards defraying the cost of maintaining the "institute" and insuring themselves a place later on, much as they carry insurance; (ii) that laboratory, study, and, if necessary, living space be made available; and (iii) that the institute be established in a community having a mild, even climate throughout the year.

The benefits to be obtained would be numerous; not the least of them would be the creation of an atmosphere conducive to further utilization of the scientists' experience and knowledge and to reflective writing. It is also likely that younger scientists and students from all over the world might wish to work side by side with men they have heretofore only been able to read about. In addition, retired scientists at this institute might also be available to assume secretariat positions for the organization of various scientific meetings.

RALPH D. TANZ
Department of Physiology, School of Medicine, Western Reserve University, Cleveland, Ohio

Blood-Group Determinations of Ancient Tissue

In the article entitled "Blood groups of the ancient dead" [*Science* **131**, 699 (1960)], Madeleine Smith raises numerous questions. We wish to comment on the interference of environmental factors with blood-group determinations of ancient tissue. The author suggests that "analysis for rare sugar components of bacterial cell walls may show whether inhibition can be attributed to bacterial contaminants or not. . . . [This theory] would appear to offer at least a partial solution to the problem."

It is not evident from present information how rare sugars could serve as an indication of the origin of a given blood-group activity. Numerous bacteria possess polysaccharides immunologically and chemically similar to A and B substances and also to H(O) substances, as do many higher and lower animals and some higher plants. With the exception of blood-group-active substances in higher plants, there is at present no indication that blood-group activity is associated with any sugars other than those found in human blood-group mucoids. Conversely, contaminants from bacteria and higher plants containing rare sugars may be present in a tissue in large amounts without being blood-group-active.

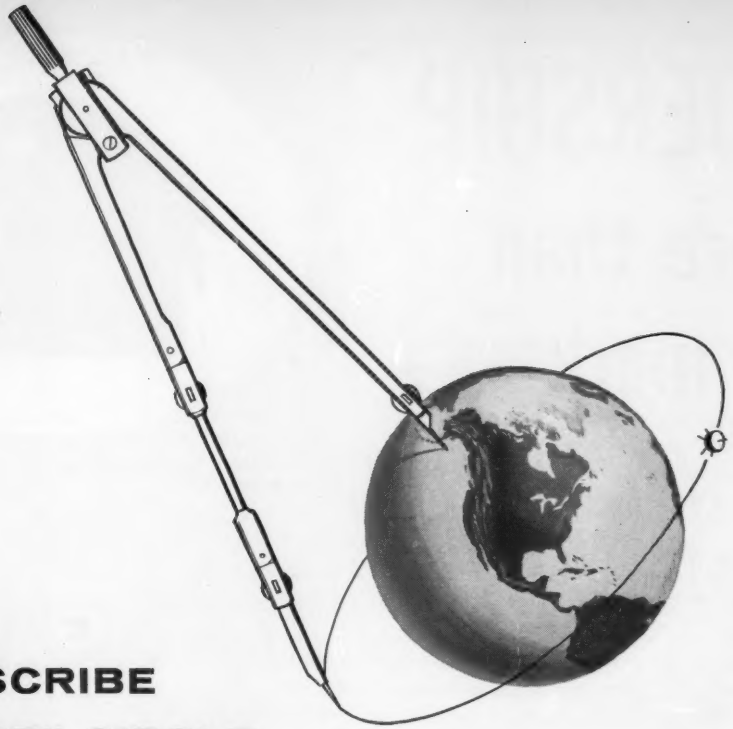
As to the enzymatic action of microorganisms on blood-group substances, destruction of blood-group A, B, and H(O) specificity by these agents is much more common than transformation of A and B into H(O). Other blood-group substances, such as the M and N referred to by the author, are destroyed by proteolytic enzymes of animal and plant origin as well as by sialidase from bacteria and viruses.

Although the leaching process in soil is mentioned, alkalinity and acidity of the soil have a more direct effect on the stability of blood-group antigens. The serologically specific glycosidic linkages are extraordinarily acid-labile, while the hexosamines are sensitive to the action of even weak alkali.

GEORG F. SPRINGER
PETER WILLIAMSON
William Pepper Laboratory and Department of Medical Microbiology, University of Pennsylvania, Philadelphia

I am glad to know that my paper has been of interest to Springer and Williamson. Their comments are most helpful in drawing attention to some of the major problems in this work. I should like to make clear, however, that it was not suggested that rare sugars should "serve as an indication of the origin of a given blood-group activity." In the presence of a reaction which might be interpreted as evidence of the presence of blood-group antigens, analysis for the rare sugars of bacterial cell walls could show whether the presence of bacterial antigens must also be postulated. It is some added evidence that the reaction is due to the blood-group antigens if these sugars are absent, although it is not claimed that such evidence is conclusive or exhaustive. It merely constitutes an added aid in the assumption that any group-

(Continued on page 1897)



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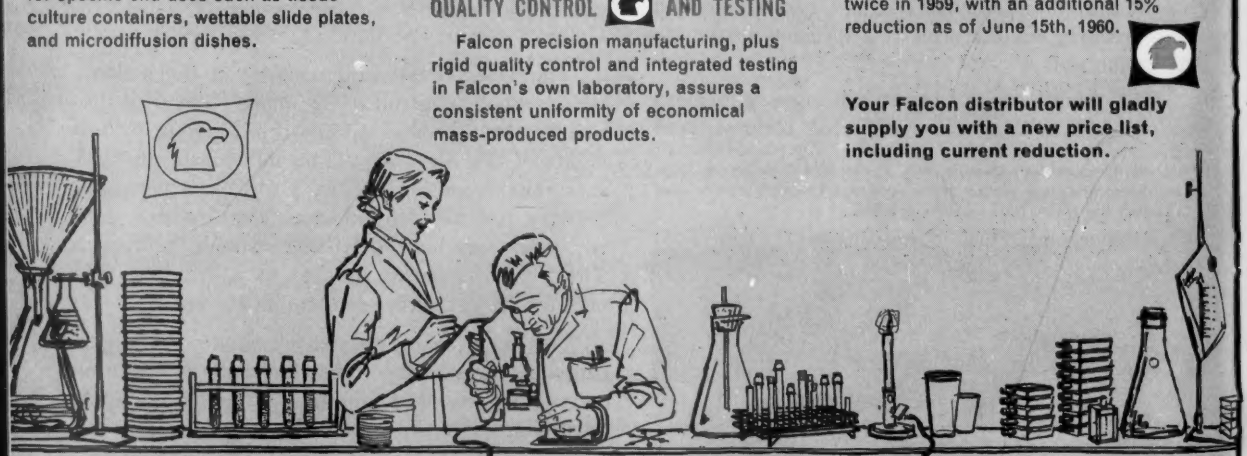

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To the Detriment of None

In Paris in mid-May, delegates from 33 nations (including the Soviet Union and the United States; Israel and the United Arab Republic) brought to conclusion a harmonious and highly successful meeting. Although there were minor differences, there was general agreement about the major problems to be attacked and about the importance of continued international cooperation. The meeting was held at UNESCO House, not at the Palais de Chaillot; the delegates were scientistss, not heads of states; and the subject was the application of science to human welfare, not international politics.

Since 1951 UNESCO has been concerned with the problems of arid lands, which, if semi-arid regions are included, comprise about one-third of the land area of the world. In 1956 UNESCO organized a six-year attack on these problems, concentrating on the deserts of North Africa, the Middle East, and Southeast Asia. The Paris meeting was designed to appraise the progress so far, to facilitate exchange of information, and to decide whether to continue along the same lines beyond 1962.

Reports from the conference show steady advance in research results, point up some difficulties, and suggest some new undertakings. Although progress has been made in desalting water for irrigation, the best methods are still some ten times too costly. A cheap source of power is still to be developed; improved methods for converting the energy of sun and wind into usable power have been devised, but none is yet economically practical.

The difficulties in reclaiming deserts are formidable. Artificial induction of rain is still in the experimental stage. Irrigation brings in its wake salt and silt and, as B. P. Uvarov of the United Kingdom pointed out, creates an environment that favors catastrophic increase of desert insects, especially locusts.

Luna B. Leopold of the U.S. Geological Survey warned that the semi-arid southwestern region of the United States is, thanks to rapid agricultural and industrial expansion, depleting its underground reservoirs as it draws water from them at much more than replacement rate.

A sharp change in the direction of thinking about desert reclamation was voiced by Gilbert F. White of the University of Chicago. A decade ago trees were planted to anchor shifting sands and to provide favorable agricultural environments, but some trees, the tamarisk for example, use more water than do crops and they should be planted sparingly.

White also pointed out that technology itself will not be enough. Social attitudes toward the use and misuse of water must be modified: "The human problems are more difficult than the technical."

Among the proposals put forward for new projects were the following: a cooperative international pilot project in a particular desert area to determine what is possible, to "recreate the Garden of Eden"; a survey of underground water resources in North Africa; the creation of an international laboratory (or phytotron) for studying plants in a controlled environment; and extension of arid zone research to South America.

The course of future arid zone research under UNESCO's auspices cannot be forecast, but from the tone of the conference there can be no doubt that cooperation among scientists of many disciplines and many countries will continue, to the detriment of none and to the ultimate gain of all.—G.DuS.

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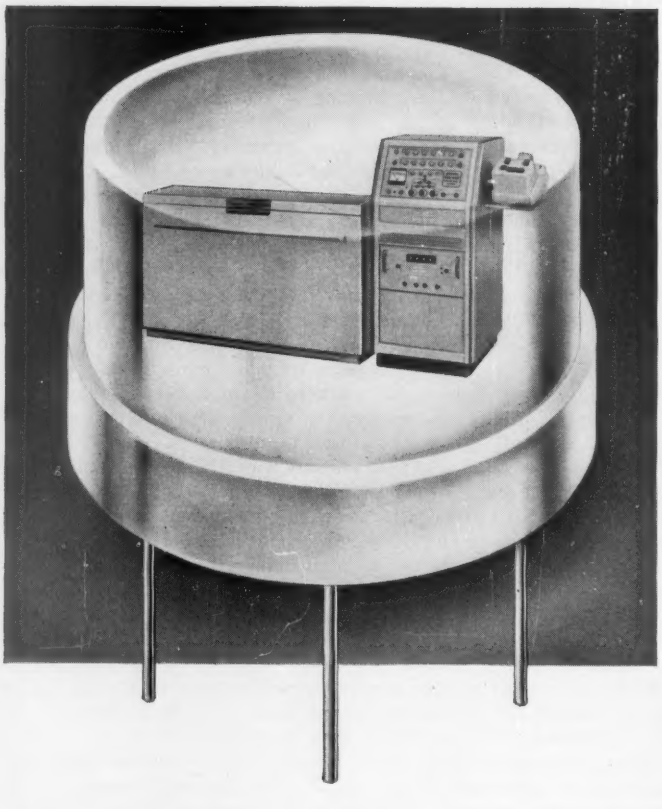

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CURRENT PROBLEMS IN RESEARCH

Translocation of Particles within Plants

The translocation systems of plants can move particles that vary in size from the ionic to the macromolecular.

J. W. Mitchell, I. R. Schneider, H. G. Gauch

Many kinds of chemicals are absorbed when they are applied to the roots or to the above-ground parts of plants. Once inside, some of these substances are readily translocated from one part of the plant to another. An understanding of these two processes, absorption and translocation, aids in the development of effective and safe methods of using chemicals in crop production. The subject of translocation is of particular interest to food technologists, plant pathologists, physiologists, entomologists, weed research scientists, and those engaged in the commercial production of chemicals that are applied to crop plants.

The present article sets forth some background information about translocation and presents some typical problems that confront investigators engaged in this type of research. Translocation of externally applied substances is viewed here mainly from the standpoint of the ability of plants to translocate particles that vary widely in size, ranging from ions through the relatively large particles exemplified by viruses. It should be emphasized, however, that factors other than size influence the translocation of a compound—for example, the chemical characteristics of a substance or the environment under which the plant exists.

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Ions

Ions, such as potassium and magnesium, usually enter the plant via the roots, but they may also be supplied as a nutrient spray to the above-ground parts, leaves and stems. Movement of ions within the plant may involve different tissues, depending on whether they entered the roots or the leaves.

In considering, first, the movement of ions from the root, it is necessary to consider how the ions entered the root and where they are located. The cell wall, composed primarily of cellulose, may be easily permeated by most substances, and thus ions can readily enter as far as the cytoplasm which lines the inside of the root cells (*1*). At the juncture of the cytoplasm and the cell wall there exists a special structure of the cytoplasm, "plasmolemma," which constitutes a differentially permeable membrane. This three-layered membrane is thought to be a lipoid layer about 50 angstroms thick with layers (each about 70 angstroms thick) of protein on each side which stablize the lipoid layer (*2*). For ions to enter the cytoplasm they must traverse this membrane except where fine strands of cytoplasm, plasmodesmata, extend through the walls of adjoining cells (*1*). The omnipresence of plasmodesmata has not been established, but plasmodesmata have often been found to connect the cytoplasm of contiguous plant cells.

Ions may move into the cytoplasm by diffusion or exchange for ions in the cytoplasm. In most parts of the cytoplasm the ions are considered to be in the "free space"—that part of the tissue or cell that is in free diffusion communication with the environment and without major permeation barriers (*3*, *4*). Ions in this portion of the cell can return readily to the environment or be translocated to the tops of the plants after movement to the xylem (wood) vessels (*5*). Ions enter this area by means of one or more physical processes and do not directly require metabolic energy in order to accumulate.

Lining the vacuole or cell sap, however, is another differentially permeable membrane called the "tonoplast." Movement of ions through the tonoplast apparently depends on the action of "carrier molecules," and accumulation in the vacuole appears to depend on metabolic energy from aerobic respiration (*5*). Metabolic energy is required for the production and maintenance of the carriers, as well as for the "active" accumulation of ions by the vacuole (*5*). Current evidence indicates, however, that ions make essentially a one-way trip when they pass into the vacuole and hence are not free to move to the tops of the plant. It has, therefore, been postulated that the ions which move to the top of the plant are the ones which "escape being absorbed [into the vacuoles] by the roots!"

In the movement of ions upward through the plant, one may therefore be concerned with ions outside the vacuoles—that is, those in the "ap-

parent free space" of the cell. It is generally agreed that the main pathway for the upward movement of ions is the xylem, but there is only speculation as to how and why the ions move across the intervening cells of the root and finally are deposited into the xylem vessels (*1*, *5–7*). It has been suggested that the inner, living cells near the xylem produce a volatile, endogenous inhibitor which prevents accumulation of ions by those cells and actually permits the movement of ions into the xylem vessels (*4*). This hypothesis is in contrast to the older theory which proposed, as an explanation for transfer of ions to the xylem, decreasing oxygen or increasing carbon dioxide concentrations in the innermost cells next to the xylem as compared with the concentrations in the surface cells of the root. Once the ions are in the xylem vessels, they appear to be carried along with water in the "water stream." There are not, however, equal rates of upward movement of ions and of water, and hence it is clearly indicated that water and salt absorption and water and salt movement are independent processes. Under most conditions upward movement of ions in the xylem is rapid, as indicated by the fact that radiophosphorus applied to the roots of tomato plants 6 feet tall appeared at the tips within 40 minutes (*8*). Movement of ten different ions from the roots to the tops of tomato, soybean, and tobacco plants was independent of aerobic mechanisms in the root (*9*).

In the upward movement of ions in the xylem there appears to be relatively little lateral movement. Ions supplied to a given root tend to appear in a branch or branches located directly above that root.

Downward Transport of Ions

Downward movement of ions may occur after the application of nitrogen, phosphorus, iron, magnesium, and some other elements to the foliage. "Foliar nutrition" is currently attracting considerable attention. Ions may also move out of a given leaf if a deficiency of a given element develops elsewhere in the plant or if the leaf becomes senescent. Current evidence, much of it being obtained with radioactive elements or with compounds containing radioactive elements, indicates that movement of ions from leaves is via the phloem. When an ion reaches the stem, it may continue in an upward or downward direction in the phloem (*6*, *10*, *11*). Interestingly enough, if two or more ions are supplied to a leaf, their movements in the phloem of the stem may be in different directions simultaneously or in the same direction, but at different rates (*12*). Such observations immediately raise a question concerning the nature of movement of ions in the phloem, since such phenomena are quite different from the unidirectional "sweeping along" of ions in an upward direction in the xylem. The rate of movement of ions in the phloem is much too rapid to be explained on the basis of simple diffusion (*1*, *13*). Radiophosphorus and photosynthate have been observed to move downward in the phloem at rates of 21 and 100 centimeters per hour, respectively (*13*, *14*).

One of the most plausible explanations for the rapid and even bidirectional movement of ions in phloem is the rapid movement of ions along interfaces. Rates of 20 centimeters per second (almost 0.5 mile per hour) have been observed along liquid-liquid interfaces, and there are many liquid-liquid interfaces and one liquid-solid interface for such movement in each sieve tube of the phloem (*15*). The addition or withdrawal of an ion or any other constituent at any one point immediately sets in motion a redistribution of that ion or constituent throughout the interfaces. Simultaneous, bidirectional movement of two substances, for example, is possible with this type of mechanism (*2*). Bidirectional movement need not necessarily occur in a single sieve tube, since various sieve tubes in a strand of phloem could carry materials in opposite directions (*11*). In cucurbits, where "inner" and "outer" phloem occur, there is evidence that the inner phloem may conduct in one direction while the outer phloem is conducting in the opposite direction (*16*). Seemingly, this movement over interfaces might be involved, although some researchers feel that the entire mechanism of translocation in the phloem is still obscure (*17*).

Admittedly, there are certain observations which are difficult to explain solely on the physical basis of movement over interfaces (*16*). Inasmuch as the sieve tubes of the phloem are living, active metabolism is occurring. Phloem is functional only when alive, and substrate, such as sugar, is essential for these cells. The "integrity" of the protoplasm is undoubtedly altered when phloem cells are killed, and the natural organization of the protoplasm is apparently required for the type of translocation under consideration. It is difficult, however, to rule out a direct relation between translocation of ions and sugar movement. Radiophosphorus and $Co^{60}Cl_2$ move out of leaves only when "sugar" is simultaneously moving out of the same leaf (*18*, *19*). There must remain for the time being, therefore, the possibility that there is more to the mechanism of translocation in the phloem than simple movement of ions and other substances over interfaces.

Ion Movement Related to Translocation of Molecules

One of the newest leads in the problem of translocation of ions in plants is evidence that there may be an interdependence between the movements of certain ions and certain molecular constituents of the plant.

First, there is evidence that the element boron, in the form of the borate ion, facilitates or is required for the movement of sugar in the plant (*20*, *21*). The borate ion forms complexes with hydroxyl-rich compounds such as sugars. Boron increases the respiration rate of carbohydrate-depleted root tips receiving sugar, presumably by increasing the entrance and translocation of sugar to the respiring cells of the root tips (*20*). Particularly for plants in an incipient stage of boron deficiency, the addition of boron to C^{14}-labeled sucrose increases the translocation of the sucrose or C^{14}-labeled photosynthate (*20*, *22*). Boron also enhances translocation of the growth-regulating chemical 2,4-dichlorophenoxyacetic acid from leaves to other parts of plants (Fig. 1) (*23*, *24*). From several corroborative lines of research there is evidence for an effect of the inorganic ion borate on the translocation of an organic molecule, sugar. The explanations for the effect of the borate ion on the movement of sugar molecules are of interest in connection with this discussion of translocation. One explanation for the enhancement of sugar translocation by boron revolves around the fact that when the borate ion complexes with sugar, the complex behaves as a negatively charged "ion" (*21*). Possibly negatively charged sugar "ions" may pass through membranes with greater facility than neutral sugar molecules.

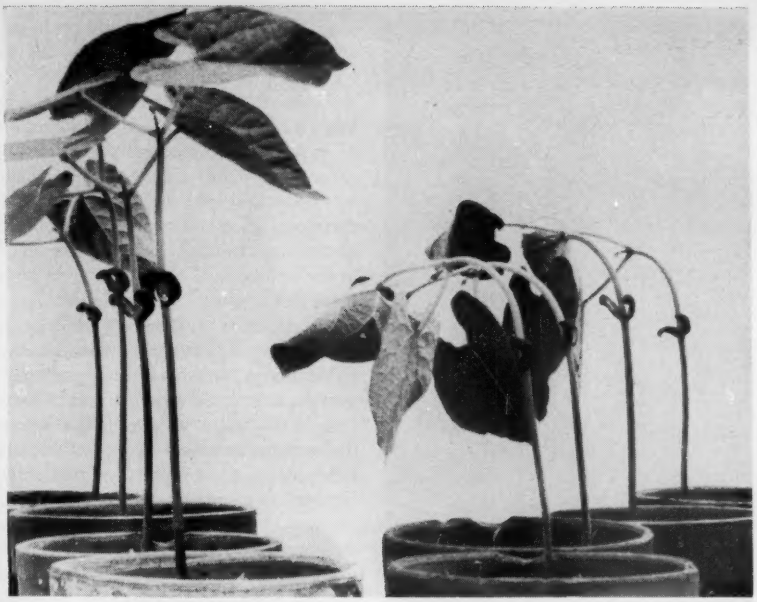


Fig. 1. Stem curvatures of carbohydrate-deficient bean plants due to application of a plant-growth-regulating chemical, sugar and boron, to the right leaf of each plant (right row) compared with curvature induced by the application of the regulator and sugar without boron (left row). The curvature indicates that translocation of the regulator, which is associated with sugar transport, was accelerated by the addition of boron.

The second explanation is that the borate ion is affixed to the differentially permeable membranes of the cell and that sugar molecules pass through the membranes over these "boron sites," with these loci or sites acting essentially as "carriers" or "assisting carriers" already present in the membrane (*21*).

Secondly, there is evidence that the interdependence between an inorganic ion and an organic molecule may be in the opposite direction, in that sugar molecules may affect the movement of foliarly applied radioactive $Co^{60}Cl_2$ (*19*). This relationship was demonstrated with carbohydrate-starved plants in the dark, and hence the effect of sugar on movement of Co^{60} may suggest only that respiratory energy is directly or indirectly required for translocation by the phloem rather than that the more specific types of action postulated for the effect of the borate ion on sugar movement occur.

Molecules

Molecules, some many times the size of inorganic ions, are sometimes readily absorbed when applied to the roots or the aerial parts of plants, then translocated in amounts that can affect either the plants themselves or insects and pathogenic organisms as these attack the plants. That aerial parts of plants can absorb effective amounts of various organic substances is evident when we realize that the usefulness of growth-regulating compounds, herbicides, and some insecticides depends on the ability of stems and leaves to absorb and translocate these chemicals. Several hundred organic compounds are known which have growth-regulating properties when applied to the above-ground parts of plants. Activity of these substances depends on the ability of plants to absorb and translocate the molecules (possibly as ions) of these substances, which are many times the size of the inorganic ions considered above. An understanding of the absorption and translocation of particles of this size is therefore important.

Inorganic substances, such as those considered above, usually dissolve readily in water, and when these substances contact the plant they are generally in relatively dilute aqueous solutions. It is thought, therefore, that these inorganic substances are for the most part subjected to the plant in the form of ions or individual molecules.

A somewhat different situation exists when organic compounds other than salts are applied to the above-ground parts of plants for crop protection or growth regulation. Many of these substances are relatively insoluble in water. Mixed with water, organic compounds such as these are probably dispersed in the water mainly as molecules or as larger particles composed of groups of molecules. Experimental evidence indicates that greatest absorption and translocation of these regulating compounds occur when these substances contact the aerial parts of plants in a nonpolar form and when the molecules are dispersed rather than clumped together (*25, 26*). It is, therefore, assumed that these relatively insoluble organic compounds enter the plant mainly as molecules.

Once within the cytoplasm of cells on the surface of the plant, molecules of the applied substance are apparently translocated through the cells rapidly. The speed is apparent when indoleacetic acid, for example, is placed on the surface of the stem of a young bean or cucumber plant. Curvature will often develop in the stem some distance from the treated area within an hour or two, indicating that movement of the compound even through cells outside the main translocation systems must have been relatively rapid. In roots and leaves, however, the actual distance traveled by the compound in passing through nonvascular tissue before it reaches a vascular system is relatively short. Movement of the substance through these nonvascular cells may be aided by cytoplasmic streaming (*27, 28*) and perhaps by the protoplasmic structures that afford interfaces over which the molecules may move rapidly (*27, 29*).

As far as the whole plant is concerned, lateral movement of molecules (from one side of a stem to the opposite side) of most organic substances absorbed by the plant is relatively limited. For example, many growth-regulating substances induce curvature when applied unilaterally to the stems of plants. The reason is that relatively slow movement of the regulator from the treated side of the stem allows cells on that side to respond to the chemical and to elongate more rapidly than those on the opposite side of the stem, farther from the site of application. One regulating substance, gibberellic acid, is an exception, however, since many kinds of plants are apparently capable of translocating this substance laterally in their stems so rapidly that the compound induces the entire stem to elongate more or less uniformly and without pronounced curvature (*30*).

Both the phloem and the xylem are involved in the vertical translocation

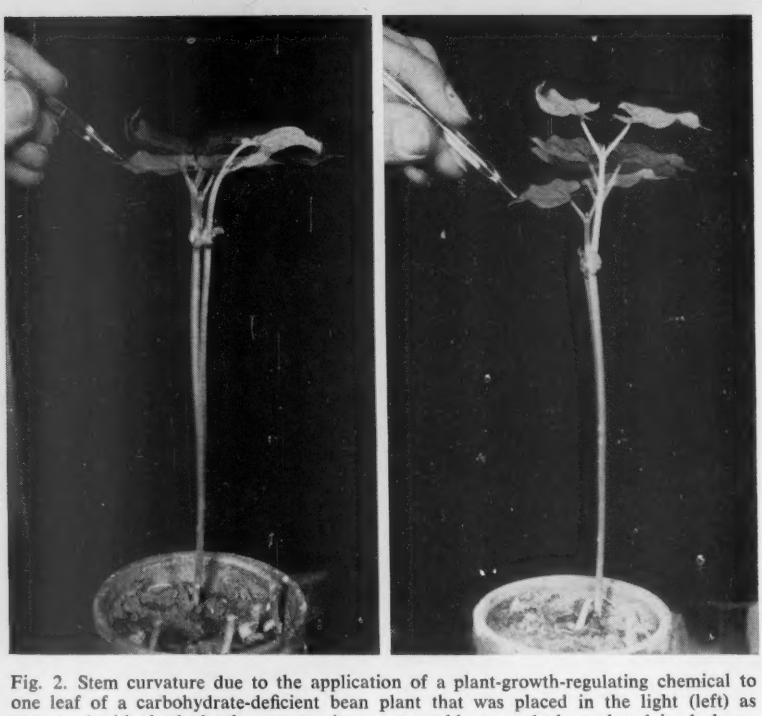


Fig. 2. Stem curvature due to the application of a plant-growth-regulating chemical to one leaf of a carbohydrate-deficient bean plant that was placed in the light (left) as compared with the lack of curvature in a comparably treated plant placed in darkness (right). The response illustrates the importance of light and of the resultant photosynthate in the translocation of regulating chemicals. The multiple photographic exposures of the same two plants were made 4, 8, and 22 hours after treatment to record progressive development of the curvature.

of some kinds of externally applied organic compounds. Many growth-regulating substances, for example, are readily transported downward in plants through phloem. These same substances are also readily translocated upward through the water-conducting tissues (*31*).

Movement of these molecular-size particles vertically in the phloem is thought to be due, on the one hand, to a mass flow somewhat similar to that which exists when a solution flows through a tube (*32, 33*). A second theory holds that movement through phloem involves living protoplasm, as discussed above—a process sometimes referred to as "active transport." In this case the molecules are thought to move through the sieve elements partly, at least, by cytoplasmic streaming. They may also move rapidly over the interfaces that exist within the protoplasm (*28*). It has also been postulated that some molecules can move vertically in the highly hydrated walls of the phloem elements, the activating force in this case being thermal activity of the molecules (*32*).

Some externally applied organic substances move readily upward through the water-conduction system of plants but less readily, or not at all, downward through the phloem. Most antibiotics and some insecticides behave in this way (*34, 35*). For this reason, these substances do not move from leaves to stems of plants as readily as do growth-regulating compounds such as 2,4-dichlorophenoxyacetic acid (2,4-D) and some chlorinated benzoic acids which are readily translocated in phloem. Molecules of all these substances are, however, apparently capable of entering the water-conducting tissue in stems or roots, where, like ions, they are carried upward through the plant in the water stream in biologically effective amounts.

Molecules of an organic compound that enter the stem may move upward fairly rapidly through the plant in the water stream. Radioactively tagged regulating substances have, for example, moved at the rate of 1 foot per minute when traveling upward in the water stream of a a bean stem (*36*). Traveling in this manner, the substance apparently can become rather uniformly distributed within the leaves of a plant. When placed directly in the water stream of a stem, the substance may build up in detectable amounts in the nearby leaves within a few minutes or, if placed on the outside of the stem, within a few hours (*24, 35*). The speed and direction of movement of externally applied organic compounds that enter the plant as molecules of moderate size are, therefore, governed partly by the ability of the plant to translocate the substance in the xylem, in the phloem, or in both tissues.

The downward transport of organic molecules of moderate size in the phloem is a somewhat more complex process than is their upward translocation in the water stream. There is first the requirement that the plant be capable of translocating that particular type of molecule in the phloem, for, as mentioned above, not all organic compounds can move in the phloem of plants in measurable amounts, even under the most ideal conditions. Secondly, translocation of externally applied organic substances from leaves of broad-leaved plants is thought to be associated with the translocation of photosynthate from the leaves (*37*). This relation between movement of photosynthate and movement of absorbed compounds can be easily illustrated by first placing a young bean plant in darkness for about 15 hours to reduce the readily available carbohydrates in its leaves. Application of 2,4-D to a leaf of such a plant will not induce curvature in the stem as long as the treated leaf is kept in darkness, where photosynthesis cannot take place (Fig. 2). Photosynthesis can be prevented, and the same result can be obtained, by illuminating the entire plant but at the same time subjecting the treated leaf to air free of carbon dioxide. When the treated leaf is illuminated and fed air containing carbon dioxide, 2,4-D is then translocated to the stem along with photosynthate and stem curvature develops. The exact nature of the relation between the regulator and the photosynthate is not known.

Mobilization of Absorbed Organic Substances

As molecules of externally applied organic compounds are absorbed and translocated from the site of application, they form a pattern of distribution within the plant. This pattern of distribution is sometimes characteristic of the particular compound. For ex-

Table 1. Distribution of radioactivity (as percentage) after application of 2-iodo^{131}-3-nitrobenzoic acid (INBA) or 2,4-dichloro-5-iodo^{131}-phenoxyacetic acid (2,4-DI) to one primary leaf of each bean plant.

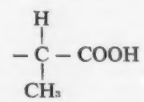
Plant part	INBA	2,4-DI
Terminal bud	60	3
First internode	12	37
Hypocotyl	28	56
Roots	0	4

ample, among those compounds that have growth-regulating properties, 2-iodo-3-nitrobenzoic acid or its metabolites accumulate in greatest amounts in the terminal buds of bean plants after application to the leaves. In contrast, 2,4-dichloro-5-iodo-phenoxyacetic acid or its metabolites accumulate in greatest amounts in the lower stems when applied in a similar manner, and relatively little is found in terminal buds of treated plants (Table 1).

Since the movement of absorbed organic compounds from leaves of broad-leaved plants seems to be closely associated with the movement of photosynthate from the leaves, it might be expected that the mobilization of photosynthate into regions of high metabolic activity in stems might also bring about accumulation of regulating substances in the same place. In fact, regions of high metabolic activity have been artificially created in stems through the application of the appropriate chemical "mobilizer," which stimulates metabolic activity. As a result, a second regulating chemical applied to the leaves is mobilized in the stems at these sites of induced metabolic activity (*26*). Thus, the distribution of 2,4-D, or its metabolites, in the stems of plants was controlled to some extent through chemically induced metabolic activity brought about by use of a second growth regulator, indoleacetic acid. Distribution of the 2,4-D was shifted from the upper part toward the lower part of the plant (Table 2). These results support the concept that the direction of transport of externally applied organic substances, such as growth regulators, is governed to some extent by the location of regions of high metabolic activity and the mobilization and utilization of photosynthate in these areas.

Metabolic activity of the type involved in the storage of carbohydrates and other plant constituents may in some instances also govern the distribution of some organic compounds absorbed by the plant. For example, when a small amount of Amo-1618—a growth-inhibiting regulator that is chemically known as (4-hydroxy-5-isopropyl-2-methylphenyl) trimethylammonium chloride, 1-piperidine carboxylate—is placed on the stem of a young bean plant, the compound is absorbed and apparently translocated very widely throughout the plant. As the plant matures, a sufficient amount of the regulator is translocated into the seeds that develop to alter very noticeably the growth of the generation of plants obtained by planting these seeds (*38*).

The ability of a plant to absorb and translocate molecules of an organic compound applied to its surface is partly, at least, related to the molecular structure of the chemical. Effort has recently been directed toward the identification of some molecular configurations that enhance intake and translocation of certain regulators. It was first learned that α-methoxyphenylacetic acid was somewhat more readily translocated in the stems of bean plants than was a closely related compound, phenylacetic acid. This pointed to the methoxy group, or possibly to a methyl group associated with an alpha carbon, as accounting for the enhanced translocatability. 3-Chloro-isopropyl-N-phenylcarbamate and isopropyl-N-phenylcarbamate were used to test the hypothesis, since these compounds are not readily absorbed and translocated downward by leaves of such plants as barley and oats. Substitution of a "lactic acid" group



for the isopropyl group in each of these compounds resulted in regulators that were apparently very readily absorbed and translocated by leaves of these plants (*39*). The "lactic acid" group is therefore of interest as one possible means of enhancing absorption and translocation of some exogenous compounds that are translocated downward in plants.

Research with α-methoxyphenylacetic acid led to the discovery that the growth regulator and several related compounds are translocated into the roots of plants and then exuded in sufficient amounts to be absorbed by the roots of nearby plants. These substances are then translocated upward by the receptor plant, which may be of the same or of a different species. The receptor plant then responds to the regulator, provided it is sensitive to the compound. Methoxy compounds that behave in this way include *m*-chloro-, *m*-fluoro-, and *p*-fluoro-α-methoxyphenylacetic acids (*40*).

Table 2. Distribution of radioactivity after application of C^{14}-tagged 2,4-dichlorophenoxyacetic acid with and without the use of indoleacetic acid. Results expressed as counts per unit of ground plant tissue.

Plant part	Without indoleacetic acid	With indoleacetic acid
Terminal bud	85	34
First internode	1060	848
Hypocotyl	2384	3289
Roots	410	509

More recently it was discovered that a different family of growth-regulating substances, the chlorinated benzoic acids, also includes compounds that are absorbed by leaves of some herbaceous plants, translocated to the roots, and then exuded in easily detectable amounts (*41*). These substances include 2,3,6-trichloro- and 2,3,5,6-tetrachlorobenzoic acids. The question as to why these methoxy and benzoic acids are exuded from roots while their structural isomers are not provides an interesting problem for future research.

Larger Particles

Plants not only translocate the small inorganic ions and organic molecules just considered but they also readily translocate much larger particles. In this section we shall concern ourselves with viruses exclusively, since translocation of these very large particles has been studied to some extent while essentially nothing is known about the translocation of nonviral particles of comparable size.

The extensive and rapid translocation of viruses within some plants contributes greatly to the severity of the diseases they cause. In many plants, however, some viruses are not translocated very far from the place where they are introduced. Although, in agricultural practice, such plants are considered resistant to these viruses, in reality the plants are highly susceptible. The failure of these "apparently resistant" plants to translocate viruses is thus very often a factor in limiting the damage the viruses cause to crop plants.

Unlike the smaller particles considered above, plant viruses are unable to enter the unbroken surfaces of the plant (*42*). Viruses are, in general, spherical or rodlike. The spherical type

range from about 130 to 1300 angstroms in diameter; the rodlike viruses may have diameters as small as 100 angstroms and are occasionally as long as 50,000 angstroms (*43*). The relatively large size of virus particles appears to explain why they enter plants only through wounds.

The size of virus particles may also have a profound influence on their translocatability. Infectious virus particles, when isolated from the plant, are typically a combination of nucleic acid and protein known as nucleoprotein. Some scientists believe, however, that only a part of this so-called "complete form" is actually translocated from cell to cell. One basis for this view is that virus particles in their "complete form" may be too large to pass readily from cell to cell (*44*). Hypothetically, the translocated forms suggested include relatively small precursory particles which become "complete virus" after transport. These particles may be infectious nucleic acid (*44, 45*). Particles composed of nucleic acid, possibly together with a small amount of protein, cause virus infections at the site of introduction (*46*). It has not been shown, however, that nucleic acid particles after translocation by the plant can cause infection.

As for the detection of virus translocation, it is the "complete virus" particle that is detected. This fact brings up an interesting contrast in the detection of translocation of virus particles and translocation of ions and molecules. When molecules of a substance are applied to leaves, for example, some of these are absorbed and then translocated to other parts of the plant, where they accumulate in concentration to a detectable level. The very same molecules originally absorbed by the leaf are therefore detected when they accumulate in other parts of the plant. On the other hand, when virus particles are introduced into a leaf, these introduced particles are immediately involved in the production of new virus particles. The detection of virus transport is in reality, then, the detection of newly formed virus particles after translocation, infection, and multiplication have occurred.

This indirect measurement of virus transport does not indicate the amount, or the exact rate at which virus is translocated. The method is, however, a very sensitive one. Infection by a single translocated particle, which by itself is not detectable, can presumably result in the production of easily detectable amounts of virus.

There are pitfalls, however, connected with the interpretation of results obtained through this indirect method of detecting virus translocation. For example, the absence of infection after virus transport will generally prevent the detection of any virus movement. Furthermore, the rate of multiplication before, after, or during translocation affects the time required for the detection of transport without affecting necessarily the rate of movement of individual particles.

Pathways Followed by Viruses

In considering the pathways of virus transport, three major interconnected routes are available. Epidermal and parenchymatous cells, interconnected by means of plasmodesmata, provide one pathway (*42*). These cells provide for the translocation of virus particles to vascular tissue in the leaf. In the stem, such cells can provide vertical transport and also lateral transport, which may finally carry the virus to vascular tissue. Movement or spread of virus via this first pathway alone is very slow, even though virus increase occurs concurrently. Virus spread by this means in a leaf may be no more than 2 millimeters per day (*42*). Although higher rates of spread may occur, this pathway is insufficient in itself to provide for the rapid transport of virus throughout the plant.

In the second pathway of transport, the phloem, individual virus particles are transported much greater distances and much more rapidly than in parenchymatous cells (*42*). Particles can move out of a leaf, upward and downward through the stem, and then back into other leaves via the phloem. Virus may pass through long sections of stem without being detectable. Movement of a relatively few particles without intervening infections and virus increase probably explains these results. It has even been suggested that virus may not multiply in sieve tubes, where the rapid long-distance transport is presumed to occur (*47*). In support of this idea, virus *x* of potato was readily transmitted downward through an intermediate section, considered immune from the virus (*48*). The virus could not subsequently be recovered from the intermediate scion.

Phloem provides for the rapid long-distance transport of many plant viruses. Some data indicate that tobacco mosaic virus can move at least 7 inches per hour in tomato stems, and curly top virus at least 60 inches per hour in the phloem of beet leaves (*42*).

Although viruses may be translocated upward or downward in the phloem, there is considerable evidence indicating a correlation between directional translocation of carbohydrates and viruses in the phloem (*42*). As with particles discussed in other sections of this article, the bidirectional and independent movement of some viruses through phloem is suggested (*49*).

A third pathway of transport is the xylem, presumably the water-conducting cells of the xylem; but the xylem has generally been considered unimportant as a pathway involved in the rapid systemic invasion of plants by viruses. There is, to be sure, considerable evidence against the upward translocation of one virus—namely, tobacco mosaic virus—by this route (*50*). On the other hand, Pierce's disease virus moved upward in the xylem of alfalfa at the rate of about 10 inches per hour, and southern bean mosaic virus moved upward in bean plants by this route at the rate of 12 inches per minute (*51, 52*). Other evidence indicates that bean plants do translocate southern bean mosaic virus upward in the dead xylem elements (Fig. 3) (*52*). It is known, then, that at least two viruses are translocated rapidly upward in the xylem. There is also evidence that viruses may differ in their translocatability even after being directly introduced into the water stream (*53*). Whether the size, and perhaps the shape, of different virus particles, as well as other factors, influence their ability to move with the water stream is not known.

The biological interactions between viruses and their hosts influence significantly the distribution of virus. For example, viruses may be more or less restricted to the phloem (curly top virus), more or less restricted to the xylem (Pierce's disease virus), or able to invade most living cells of all plant tissues, including the phloem and the xylem (mosaic viruses) (*42*). Restriction of some viruses to certain tissues does not necessarily indicate the inability of the plant to translocate virus particles to other portions of the plant by the various pathways indicated. Restriction to certain tissues may only indicate the inability of the virus to "survive," infect, or multiply in detectable amounts

in the "noninvaded tissues." Virus distribution may also depend on where the virus is placed, and insect vectors play a role, since different ones feed in different tissues (*54*).

Efforts have recently been made to learn more about the translocation pathways available to virus particles as affected by the site of introduction of the virus. To start with, this study of translocation pathways was carried out by using southern bean mosaic virus and a "local-lesion-responding host" (pinto bean) in which the virus does not ordinarily move far from the inoculated area. With conventional inoculation of southern bean mosaic virus into superficial leaf cells, necrotic lesions a few millimeters in diameter result. The virus multiplies and spreads to some extent, but most of it remains localized in these affected areas. After the inoculated plant grows to maturity, the entire plant (except the inoculated leaf) remains free of detectable virus (*55*). Presumably, under these conditions virus particles do not reach vascular tissues.

The stem is another portion of the pinto bean plant in which superficial cells can be infected with southern bean mosaic virus without extensive translocation of the virus (*56*). Although the spread of this virus after superficial stem inoculation is somewhat more extensive and sometimes more rapid than that after leaf inoculation, the major portion of a mature plant remains free of detectable virus. With the superficial stem inoculation, the virus moves only a few inches from the area where it is introduced (*52*).

When southern bean mosaic virus is introduced deeply rather than superficially into the lower portion of a stem, very rapid translocation of virus occurs (*53*). Infectious particles are then carried several feet upward to the top of the plant, and thus they reach parts not ordinarily invaded as the result of superficial inoculation of the lower stem (*57*). Dead xylem elements are the cells in which this extremely rapid upward translocation occurs. Just how these translocated virus particles finally leave the dead xylem elements and enter living cells is not known. It is evident that a pathway between the dead and the living cells exists, however, since new infections occur in relatively young leaves located in the uppermost part of the plant. No infections occur, however, in the more mature lower leaves, although these also contain translocated infectious virus particles. Some of these particles remain infectious in these mature leaves for at least 2 weeks without multiplication of the virus unless the leaves are wounded to initiate infection (*52*). These results suggest that the virus particles are unable to leave the dead elements in the older leaves although they are able to do so in the younger ones.

By introducing virus particles deeply within the stem, infections initiated many feet above are caused by the particles introduced rather than by new particles formed at the site of introduction (*57*).

Still another technique for virus introduction has been used to study virus translocation. Southern bean mosaic virus may be introduced deeply in the stems of pinto bean plants by means of graft unions. This introduction results in an even more extensive invasion of the receptor bean plant (pinto variety) than is observed when the previously discussed methods of introduction are used. This technique results in rapid long-distance transport of virus particles, probably in the phloem as well as in the xylem of the pinto bean plant (*58*). In this way, the closest approach to a systemic invasion by southern bean mosaic virus in pinto bean has been obtained. Nevertheless, preliminary data indicate that the mobility of southern bean mosaic virus is not as complete as it is in a systemic host, even after virus particles enter both xylem and phloem.

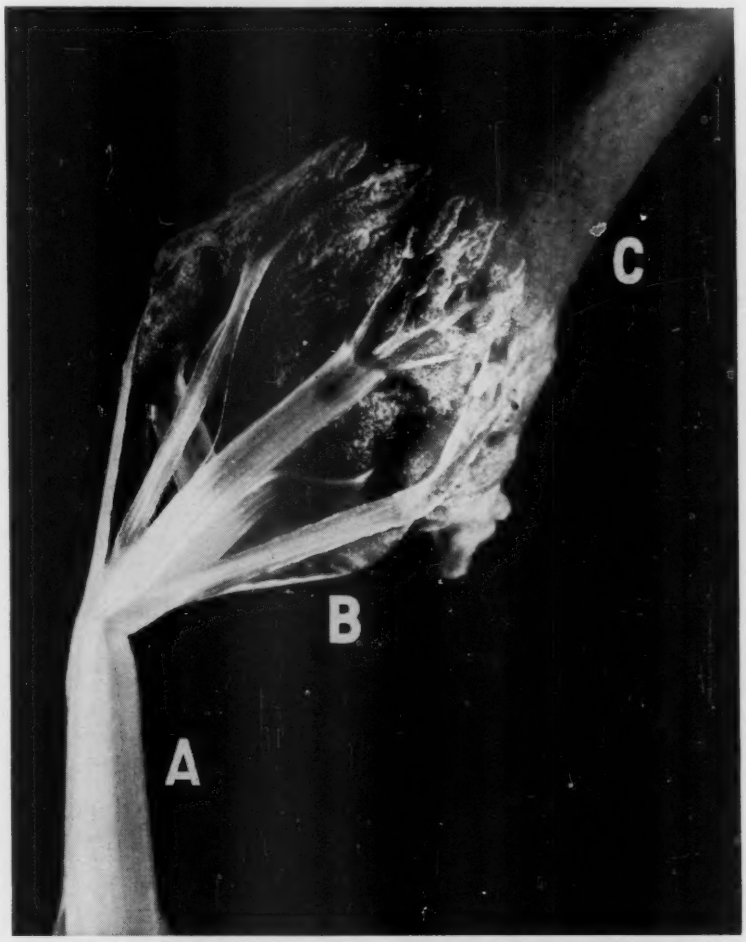


Fig. 3. Steam-killed portion of a bean stem (*A*) connected only by strands that include dead water-conducting cells (*B*) with the upper living portion of the plant (*C*). Southern bean mosaic virus particles passed upward from the lower living part of the plant through (*A*) to (*C*) and above, demonstrating translocation of this virus in the nonliving water-conducting cells.

Summary

To summarize our consideration of translocation, it is evident that plants have very effective translocation systems capable of rapidly moving very small particles, such as potassium ions, which are only about 2 angstroms in diameter, or of moving relatively large particles, some even as long as 20,000 times the diameter of a potassium ion. At the small end of the size scale the dimensions of particles may not influence their translocation, but when particles farther up the size scale (molecules) are involved, dimensions may become more important. At the large end of the size scale (macromolecules), dimensions may be critical. Although we have learned some facts about mechanisms involved in translocation, many questions still remain. The answers that afford an understanding of translocation from a broad viewpoint will necessarily explain how plants translocate particles that vary so widely in size as well as in other characteristics.

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British Achievements in X-ray Crystallography

Knowledge of the precise geometry of molecules opens new possibilities for understanding chemical reactions.

W. L. Bragg

X-ray crystallography is a technique by which the arrangement of atoms in various types of substances, and particularly in crystals, is deduced by studying the manner in which these substances scatter a beam of x-rays. This study became possible when the German scientist von Laue discovered x-ray diffraction by a crystal in 1912. The rays from a roentgen-ray tube were concentrated in a narrow beam by passing them through a fine hole, and when this beam fell on a crystal, and the scattered rays were recorded by a photographic plate, the photographs showed a symmetrical pattern of spots. Von Laue correctly interpreted this effect as due to the "diffraction" of x-ray waves by the regular pattern of atoms in the crystal.

This discovery was a crucial event in the history of science. In addition to proving conclusively that x-rays are electromagnetic waves like light, and leading to the study of the characteristic x-ray wavelengths emitted by the elements, which played a key part in subsequent research into atomic structures, it made it possible to analyze the structure of matter in a new and very powerful way.

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Optical Grating Principle

The effect is due to the same principle which governs the production of spectra by a diffraction grating. An optical grating consists of a number of fine lines ruled regularly on a glass or metal plate. When light falls on such a grating, each line scatters a wavelet. In certain directions, depending on the spacing of the grating and the wavelength of the light, the wavelets combine so that their crests and troughs coincide, and in these directions a strong beam of light is scattered. In other directions there is no such fit, the waves cancel each other's effects, and there is no scattered beam. This is the principle of "interference" enunciated by the famous Thomas Young in the first years of the 19th century, who first clearly demonstrated the wave nature of light. Many of the most beautiful colors in nature, such as the iridescent sheen on some beetles, the blue of a butterfly's wing or a jay's feather, the play of color in mother-of-pearl or, more strikingly, in an opal, are due not to pigments but to interference.

No new optical principle is involved in x-ray diffraction, but there is a contrast in emphasis. An optical grating is used to analyze light; the grating diffracts light of each wavelength in a characteristic direction. A very simple pattern of regular lines in the grating is used to analyze a complex spectrum consisting of light of many different wavelengths. In x-ray analysis, on the other hand, we wish to analyze the grating. The simplest possible spectrum is used—a monochromatic x-ray beam consisting of a single wavelength. This falls on a complex grating composed of atoms arranged in some kind of regular pattern in three dimensions. The aim is to deduce the atomic arrangement from the directions and intensities of the scattered beams or "spectra."

It would be out of place to outline, in this article, the rather complicated geometry of the effect. It may perhaps suffice to say that every variation of atomic pattern produces a characteristic pattern of x-ray diffraction which we can calculate, so by observing the latter we can deduce the former.

One point may be noted. Nature has been kind to us in providing a scale of dimensions that is just right. X-ray waves are about 1/1000 as long as light waves, and their wavelength is of the same order of magnitude as the distance between atoms in crystals. This is precisely the right condition for the interference of the waves scattered by the different atoms in the crystal, which are regularly arranged like soldiers drawn up on parade or the pattern of a wallpaper.

This new art of x-ray analysis has cast a flood of light on problems in many branches of science. Chemists are able to tell us the proportions of the elemental atoms which build up chemical compounds. In some cases, in particular in the case of the compounds of the element carbon, they can discover which atom is linked to which. But x-ray analysis goes further; it gives us a map or blueprint of the structure, with each atom in its correct place, so that we can see how it is surrounded by its neighbors and how far away they are. Just as a blueprint explains to an engineer how a machine works, so this map makes it possible for the scientist to understand why bodies possess the properties they do and how they interact with each other.

In *The Ethics of the Dust* Ruskin explained to his class of young ladies what fascinating patterns they would find if only they had a way of magnifying a speck of dust so greatly that they could see the patterns of its building stones or atoms. His fantasy has now become fact.

Scientists in all countries have made contributions to the art of x-ray analysis, but it can be claimed that the United Kingdom has played a leading part. The first analyses were made in the United Kingdom, and up to the present a large proportion of the major advances in applying it to increasingly complex problems have had their origin in British laboratories. In reviewing the structures which have been analyzed we can play a kind of "animal, mineral, and vegetable" game, though these are not quite the categories we want. The convenient ones are "inorganic" (oxides, salts, minerals), "organic" (the compounds of carbon), "metallic" (metals and alloys), and finally "biological" (the vast number of molecules which play a part in life processes).

Inorganic Compounds

Most of the first structures to be analyzed were inorganic, because they were simple. The first of all was the structure of rock salt, or sodium chloride (NaCl), shown in Fig. 1, where

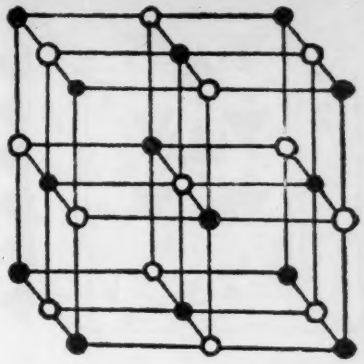
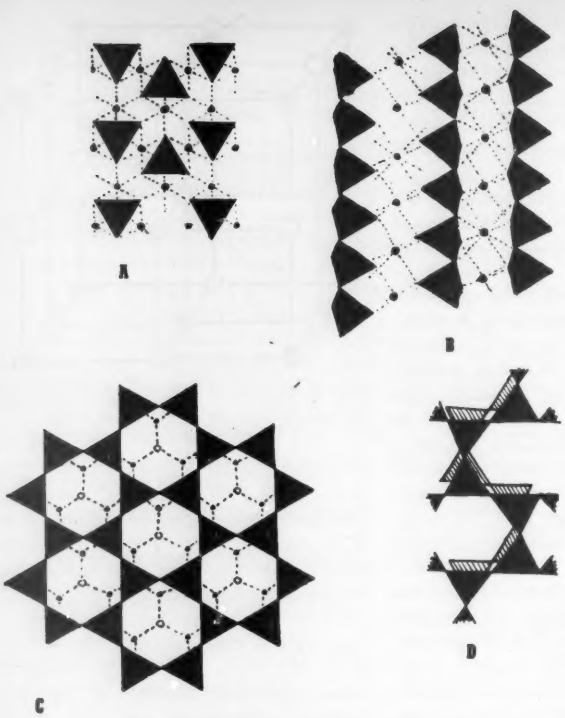
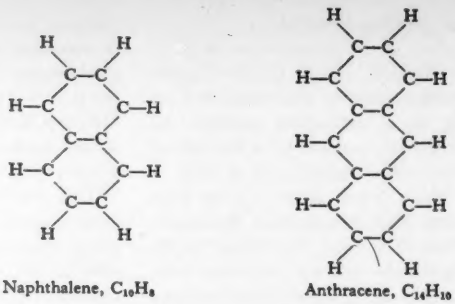


Fig. 1. The structure of rock salt (sodium chloride).

the open and solid "spheres" show the position of the centers of sodium (Na) and chlorine (Cl) atoms. Innocent though this structure may appear, it caused something like a minor chemical revolution. A cornerstone of chemistry is the conception of the molecule, the basis of Dalton's atomic theory. The vast numbers of different chemical compounds are built from comparatively few elements. Dalton postulated that each pure compound is composed of identical molecules, each molecule being a small family party of various atoms united together as a group. For instance, sodium chloride was held to be composed of molecules each containing one atom of sodium and one of chlorine. But, in the structure shown in Fig. 1, where is the molecule? Each sodium atom (Na) is surrounded equally by six chlorine atoms (Cl), and each chlorine atom by six sodium atoms, in a kind of three-dimensional chessboard pattern, and there is nothing to indicate that one sodium atom is particularly linked to one chlorine atom.

The answer, as is now realized, is that the structure is composed of charged atoms or ions, sodium being positive and chlorine negative. It is the electrical attraction of these opposite charges which holds the structure together, and of course each positive tends to be surrounded by negatives, and vice versa. The equality in numbers of sodium and chlorine atoms comes, not from paring of one sodium with one chlorine atom, but from the fact that the electrical charges must balance. So there is no molecule; it is as if, having found that the numbers of ladies and gentlemen at dinner parties is generally equal, we had falsely





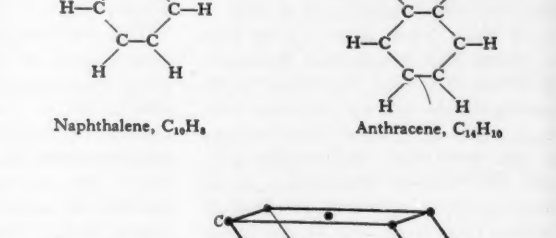
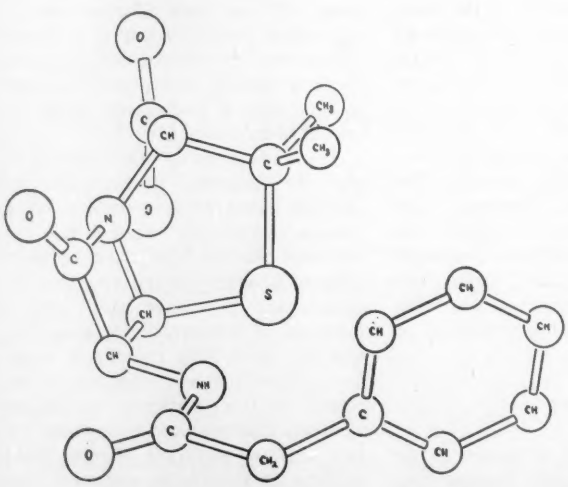


Fig. 2 (left). Schematic representation of the main silicate structures. (*A*) Isolated groups; (*B*) chains; (*C*) sheets; (*D*) three-dimensional frameworks. Fig. 3 (above). Naphthalene and anthracene.

concluded they were all necessarily married couples, instead of realizing that it was because each lady liked to have a gentleman on either side, and vice versa. It was a hard fight to get the idea accepted. I remember well how we were begged by the chemists to find some inclination, however slight, of a sodium atom to the chlorine atom to which it properly belonged!

The idea of inorganic compounds being composed of ions has given a new slant to inorganic chemistry. It has its most striking application in the structure of the minerals. The most common elements, which form by far the greatest proportion of the earth's crust, are oxygen, silicon, and aluminum. Sand, for instance, is mostly silica or quartz, a substance made up of silicon and oxygen in such a way that there are twice as many oxygen ions as silicon ions. These are highly charged ions with strong attractions. Silicon is al-



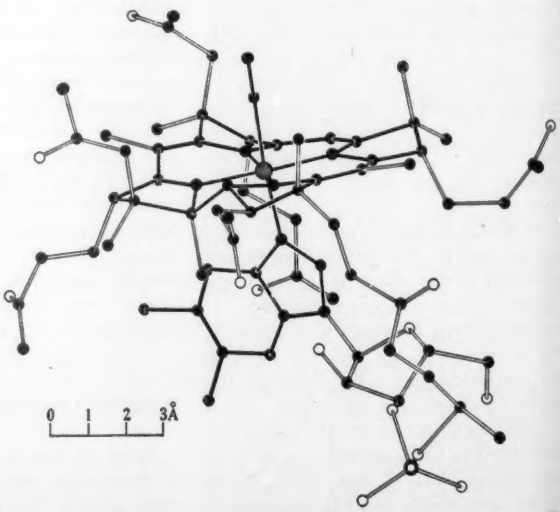


Fig. 4 (above). Structure of penicillin. Fig. 5 (right). Structure of vitamin B_{12}.

ways surrounded by four oxygen atoms at the corners of a tetrahedron; aluminum, sometimes by six at the corners of an octahedron (like two pyramids joined base to base) and sometimes by four, like silicon. The framework of the common minerals, the silicates, is a kind of fabric of these tetrahedra and octahedra linked by the oxygen atoms at their corners.

We may compare these two types to the purl and plain stitches in knitting, which in suitable combinations can produce such complex patterns. The tetrahedra are the strongest stitches, and it can be seen at once that there must be four main types of pattern which can be built with them. They can either be separate, or joined corner to corner in a long string, or joined by three corners to make sheets, or joined by all corners to make a three-dimensional framework (see Fig. 2).

These are precisely the four great families of silicate minerals. The first is represented by the dense olivines (the jewel peridot is an olivine); the second, by such fibrous minerals as asbestos; the third, by mica and the minute spangles which form clay; the last, by the felspars, of which the pink or gray opaque crystals in a granite are an example.

These minerals, and others like them, are held together by strong forces and hence have a high melting point, and they are relatively light; hence, as the earth cooled, they came to the top and formed the crust on which we live. A knowledge of structure has turned complexity into order and simplicity. The dynamics of the structures were elucidated by the American scientist, Linus Pauling, but the main story of the silicates was worked out in the United Kingdom.

Organic Compounds

If the idea of the molecule was found to be inappropriate in inorganic compounds, it received ample support when organic compounds came to be analyzed by x-rays. These compounds are for the main part composed of carbon, oxygen, nitrogen, and hydrogen. The atoms are bound together by links which are strong and which are localized, as if each atom had places in its surface to which another atom could be bolted. The groups of atoms so linked together into a chemical molecule are bound by comparatively weak forces to neighboring molecules, hence they can be regarded as separate entities in a real molecular sense. This is in contrast to the inorganic compounds, which form a continuous structure of alternating positive and negative ions.

The analysis of organic compounds began with my father's work on naphthalene and anthracene, illustrated in Fig. 3. Organic chemists had shown that the former of these consisted of two benzene rings and the latter, of three benzene rings fuzed together. The distance between carbon atoms had been ascertained from the structure of diamond. The "unit cell" or box containing each pattern element of a crystal can be directly found by x-ray analysis, and my father was able to show that the box on the left could just contain two naphthalene molecules, that on the right, two anthracene molecules, of the form postulated by organic chemistry. X-ray analysis of organic compounds developed rapidly after this start, at first in the main confirming and making precise the pictures of organic molecules deduced by the methods of stereochemistry, and latterly revealing molecular structures which had hitherto defied chemical analysis. In contrast to this start, Figs. 4 and 5 show two recent triumphs, the positions of the atoms in moleclues of penicillin and vitamin B_{12}, determined by Dorothy Hodgkin and her colleagues by x-ray analysis in her Oxford laboratory.

Alloys

The story of alloys is very fascinating and involves quite new ideas. The basis of Dalton's atomic hypothesis was the law governing the definite proportions in which atoms combine to form compounds. This gave rise to the conception of family parties of atoms, the molecules, which we have seen to have been inapplicable to inorganic compounds but applicable to organic compounds. In alloys, the law of combining proportions no longer holds. When one metal is alloyed with another—for instance, zinc with copper —a series of different structures is formed, depending upon the proportions of zinc and copper in the alloy. Each structure is not characterized, however, by a definite ratio of the two elements; on the contrary, there is a certain range of proportions, often quite extensive, for each structure.

The reason for this is clear if we consider the peculiar nature of a metal. A metal atom is characteristically electropositive—that is to say, it has one or more electrons which are very easily detached from the atom, leaving it a positive ion. When metal atoms come together to form a metal structure, these loosely held electrons cease to belong to individual atoms and become a continuous electron sea with the positive ions embedded in it. The structure is held together by the electrostatic attraction between the positive ions and the enveloping negative electron sea. There are no bonds between atoms; that is why a metal can be distorted without breaking.

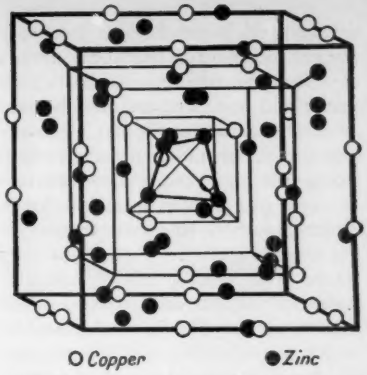


Fig. 6. Structure of brass, an alloy of copper and zinc.

The same conception explains the nonexistence of a law of combining proportions. There is no longer a need to balance the numbers of positive and negative atoms, as in an inorganic crystal, because each atom brings with it its own balancing charge in the electrons it contributes to the structure. We may liken it to one of those parties of the type where the number and balance of the guests is not of prime importance because each brings his own supply of drink. An important factor in determining the phase structure is the ratio of the number of electrons to the number of atoms. When zinc is added to copper, each zinc atom brings two electrons with it, while the copper has one, so the electron-atom ratio is increased. The phase structure, at first simple, assumes more complex forms as the amount of zinc increases. Scientists in many countries contributed to this story, but the work on complex alloys by Bradley in Manchester, and on the influence of the electron-atom ratio by Hume-Rothery in Oxford, was outstandingly important. Figure 6 shows an example of Bradley's analysis.

Biological Molecules

Biological molecules are essentially organic compounds like those already described, but for convenience they are considered in a separate class because of their size and complexity. The molecule of hemoglobin, for instance, which colors our blood red and has the task of conveying oxygen from our lungs, which absorb it when we breathe, to the muscles and other parts of the body where it is needed, has a molecular weight of 68,000 and contains about 12,000 atoms. Protein molecules, of which hemoglobin is an example, are for the most part composed of carbon, oxygen, nitrogen, and hydrogen, like all organic compounds, and also contain a few atoms of special kinds such as sulfur.

It appears that each type of protein molecule has a specific task to perform. It may be quite a simple one, like that of carrying oxygen, but the complexity of the molecule may be ascribed to the need to do this task at just the right place and in just the right way. We are reminded of the contrast between the simple letter delivered at our door and the complex of delivery van and postman, and indeed all the organization behind them, which insures that the letter reaches the right address.

A whole group of proteins called enzymes is concerned with the various chemical tasks in our bodies. Another group of biological molecules comes under the heading of "nucleic acid." It appears to be their task to act as the templates on which new protein is manufactured, and as the types of protein made determine the nature of the organism, they are the carriers of the hereditary factor in a parent, which determines the nature of the offspring.

The successful application of x-ray analysis to the study of these biological molecules is one of the wonders of modern sicence. A vast amount of brilliant research on their constitution had been done by chemical techniques; the x-ray work is based on this foundation, but it has performed its typical function of giving precision to the picture. It has been thrilling to see that x-ray analysis can be applied to such very complex bodies.

Protein Structure Analyzed

The leading x-ray group in Great Britain has been the research unit directed by Perutz and Kendrew in Cambridge and supported by Britain's Medical Research Council. Their work resulted in the first successful analysis of a protein structure (by Kendrew), the myoglobin molecule which acts as a storehouse of oxygen in muscle. It would have been almost inconceivably difficult to tackle a molecule containing 3000 atoms (myoglobin is about one-quarter the size of hemoglobin) by the x-ray techniques which had served for simple molecules.

Success was attained because of a discovery by Perutz that certain heavy atoms such as mercury, iodine, or gold could be chemically attached to specific points of each molecule without disturbing the crystal structure.

It is relatively easy to discover the positions in the structure of these heavy marker atoms, which scatter the x-rays far more powerfully than the light atoms of the organic complex. By noting the differences which they cause in the x-ray diffraction, it is possible to apply an analysis which reveals the protein structure.

It is a massive frontal assault. Vast numbers of measurements have to be made, and the results are fed into electronic computers which perform in a few seconds calculations which would take as many weeks if made by human beings. The results are just now coming off the production line, and it is a very exciting time.

Another extremely important success of the Cambridge unit was the establishment of the structure of nucleic acid by Crick and his American colleague Watson. This structure has suggested a fascinating mechanism for the processes of heredity.

Why is this so important? It is again a question of the precise picture. The functions of these molecules must be dependent upon their geometry. They must fit each other in just such a way that the right parts are brought into conjunction and can interact chemically. We hope to understand such processes when we know the structure; we hope to see how the enzymes act, why vitamins are necessary, what hormones do, why certain substances are poisonous. As in other and simpler realms of x-ray analysis, we can confidently hope that this new knowledge will result in a new flood of light being cast.

Science in the News

How Safe Is Safe? AEC Ready To Fight Challenge to Its Reactor Licensing Procedures

Two weeks ago a three-man federal court of appeals voted 2 to 1 to back the contention of three major AFL-CIO unions that a construction permit should not have been granted to build a nuclear power station at Lagoona Beach, 15 miles south of Detroit. The unions said that the AEC was wrong both on procedural grounds and on its finding that the reactor would not present an unreasonable hazard to the heavily populated areas near the station. This week the AEC was moving to appeal the decision to both the full nine-man Court of Appeals and to the Supreme Court.

The unions are not involved as representatives of men who will work in the plant, but of men who live and work and own property within a 20- or 30-mile radius of the plant site. What they are concerned about is the possibility of a major disaster that could contaminate a large area with radioactive debris. Such a disaster is conceivable just as, for example, it is conceivable that a gigantic meteorite will destroy New York tomorrow. The issue is how much assurance the AEC must be able to give interested parties, such as the unions in this case, that such a disaster will not take place.

New Evidence Has Developed

AEC officials appear to be confident that the Michigan project will be carried through no matter how the courts finally decide the case. They say that in the two years since the hearing on which the appeals are based new evidence has developed which should remove any lingering doubts about the safety of the project. The important issue, it seems, is whether the case will force a general tightening of the AEC's present licensing procedures.

At present the commission licenses reactors in two steps: it first issues a construction permit based on a preliminary finding that the reactor will be safe to operate; then, perhaps 5 years later, when the plant has actually been built, it issues an operating license after an extensive series of tests showing how the plant will run. The unions contend that the preliminary findings in this case were not firm enough to offer real assurance that the plant will not be a hazard to surrounding areas. They say that the fact that an actual operating permit has not been granted, only a construction permit, is not reassuring: that once the AEC has given a corporation the go-ahead to spend, in this case, $60 million it is going to find itself under strong pressure to grant the operating license whether the plant is as safe as it should be or not.

AEC's Dilemma

What the unions appear to be arguing is that there should be no license or permit of any sort until a project has been proved safe. The problem is, how do you define "safe"? "The possibility of [a major accident]," says the AEC brief, "cannot be categorically excluded. If the statute and the regulations are to be interpreted, as the [unions] imply, so that the Commission must be *certain* that an accident will never occur, then no developmental reactor would ever be built."

The strategy of the unions at the hearings was not to call any witnesses of its own to contradict the testimony that the reactor would be safe but merely to cross-examine the scientific witnesses testifying in favor of the reactor and get them to admit that they could not be absolutely sure that their calculations were correct, nor certain that unforeseen difficulties might not come up that would invalidate the calculations and the assumptions on which they were based.

The unions stressed the opinion of the AEC's Advisory Committee on Reactor Safeguards that "even though there are no facts or calculations available to the Committee that the proposed reactor is not safe for this site, the Committee believes that at this time there is insufficient evidence that the PRDC reactor can be operated at this site without public hazard." But, says the AEC, these same witnesses believed that the necessary further assurances could be expected to be developed during the process of designing and constructing the reactor.

Present Plants Inefficient

This, then, is the AEC's dilemma: At this time there is little point in building a power reactor unless it can be expected to be an improvement over the comparatively inefficient plants now built. This, says the AEC, makes it necessary to issue construction permits on less firm assurances of safety than will be required for the actual operating license. For how do you develop more efficient nuclear power plants if the only ones you are allowed to build are types which have already been built, since any significant new features may raise uncertainties about the hazards involved when the plant is put into operation?

The AEC is convinced that even the preliminary assurances of safety required before a construction permit is issued make an accident so unlikely that the present system of licensing presents, by any reasonable standard, no hazard to the public. The AEC and, it appears, the scientists who work on these projects, are convinced that this is true. Their problem now is to convince the courts.

Senate Group Recommends Big Increase in HEW Funds

The Senate Appropriations Committee has recommended increases of nearly half a billion dollars over the Administration's Health, Education, and Welfare fiscal 1961 budget estimates. The bulk of the increase will go to medical research. The committee had appointed a Committee of Consultants on Medical Research last year, chaired by Boisfeuillet Jones, of Emory University in Georgia. Last month the consultants recommended $664 million for the National Institutes of Health, an increase of $264 million over the Administration figure.

The Senate Committee praised the group for a "dedicated, inspired, and imaginative performance," and accepted their recommendations in full. The com-

mittee said that "these increases should be regarded not as a maximum level, but as the floor from which further advances will be made in years to come."

Other increases put the Senate recommendations at $472 million above the Administration budget estimates and $420 million above last year's spending in this area.

How much of this will actually be appropriated probably will not be known for another week or so. The Senate, working late to reach adjournment before the conventions, approved the Appropriations Committee recommendations on 17 June. The only changes made were to add another $1 million, at the request of Kuchel of California, for studies of air pollution from automobile exhausts and $700,000, at the request of Humphrey of Minnesota, for studies of the Social Security program.

Everett Dirksen, the Republican leader, told the Senate, "I think I can assure you that the President will be compelled to veto this bill." Whether this will actually happen will depend on the size of the bill that emerges from conference with the House appropriations bill. The House bill calls for substantial increases over the Administration proposals but nevertheless is nearly $300 million short of the Senate figure. In recent years Congress has consistently voted substantial increases in medical research funds, but never such sharp increases as the Senate, at least, seems anxious to grant this year.

Atomic Power in Antarctica: Everyone For It, But Nobody Wants To Pick Up the Check

A preposterous situation has developed over a proposal to build three small atomic power stations at National Science Foundation research bases near the South Pole. The proposal has the support of everyone. Senator Jackson and others have pointed out that the plan meets all three major criteria for the federal power reactor program: it will add to U.S. prestige; it will provide useful information on reactor technology; and it will be economically feasible—in fact, it will actually save an estimated $60 million over the 20-year life of the reactors, since the cost of conventional fuel is ridiculously high at the polar bases. AEC officials told the committee that, among other things, it takes 6000 gallons of aviation gasoline to fly in 3600 gallons of diesel oil. They said that the cost of conventional fuel at one of the scientific stations ran as high as $10 a gallon.

As a result, no one is against the proposal. But no one wants to pay for it out of his budget. The Bureau of the Budget says the Navy should provide the necessary $20 million out of its general funds. The Navy says it is only providing supplies for the National Science Foundation research teams, that the Bureau of the Budget should allow it to have the money in addition to its regular appropriation. Here is an excerpt from the authorization hearings in April:

Chairman Anderson: Does the statement of the AEC this morning that it can speed this up help you any with your problem of getting the reactor program going?

Captain Coxe: Senator Anderson, our problem is only financial.

Senator Jackson: We are assuming you would have funds. We would not expect you to go ahead without the money.

Captain Coxe: We have no money.

Senator Jackson: That is the purpose of this meeting today.

Captain Coxe: We need $16 million [extra].

Representative Holifield: When would you need it? . . . When would you have to make your request in order to get it in a budget?

Captain Coxe: If we put it in a Navy budget, sir—is that your question?

Representative Holifield: Yes.

Captain Coxe: The first budget we could put it in would be in the 1962 budget.

Senator Jackson: Let's dismiss this part of it right away. Captain, you know this has such a low priority, with all the other Navy items, that to talk about next year's budget is to talk about a fiction. Do you not agree?

Captain Coxe: I am inclined to agree.

Jackson said he did not blame the Navy. He said he realized that supplying fuel to the research stations was an assigned function completely outside the day-to-day activities of the Navy and that it understandably had a very low priority. The committee as a whole seemed to agree that the Navy's position was not unreasonable; that the AEC's position was not unreasonable; and that perhaps even the Budget Bureau's position was not unreasonable; but that the general situation was absurd. Last week it sent off a round of briskly worded letters to the AEC, the Bureau of the Budget, the Navy, and other agencies involved. It suggested that it did not care who took responsibility but that someone had better make a decision quickly.

The letters produced the desired effect. This week the AEC began soliciting bids for the project.

Student Non-Communist Affidavit: Repeal Voted by the Senate, House Action Unlikely

The Senate passed the Kennedy-Clark bill last week, but with only three weeks left before scheduled adjournment there appears to be no chance for action in the House. As reported here several weeks ago [*Science* **131**, 1425 (13 May 1960)], the outlook for the bill was extremely dismal in the House, but there had appeared to be some chance that a compromise measure might get through. That chance probably has been eliminated, as the bill reached the Senate floor nearly a month later than had been hoped.

The bill, as expected, passed without difficulty once its sponsors had accepted the Prouty amendment making it a crime for a subversive to accept a loan. The Senate neatly avoided the problem of making its members go on record on this touchy election-year issue by slipping the measure through on a voice vote, without a roll call. Senator Goldwater and other opponents of repeal were absent from the floor when this was done, but their absence, presumably, was intentional. Senator Dirksen, the Republican leader and a member of the committee minority that opposed the bill, was on the floor at the time, and there is no question that he would not have permitted the measure to slip through without a formal vote unless he had first cleared the maneuver with Goldwater and other opponents.

Bourke B. Hickenlooper made the most remarkable speech of the debate. He argued, by a process of reasoning which was difficult to follow, that to repeal the affidavit would be tantamount to inviting college professors to teach the violent overthrow of the government. Dodd of Connecticut probably echoed the feelings of the sizable number of senators who did not seem to feel strongly one way or the other but nevertheless were willing to go along with the repeal. In a speech largely devoted to defending the affidavit, Dodd said he nevertheless planned to vote for repeal. "There is something about this affidavit," he said, "which seems to me to violate good taste."—H.M.

U.S. Offers Aid to Seismographic Stations Participating in Global Net Using Standardized Equipment

The United States recently announced plans to provide modern, standardized seismic equipment to 125 seismographic stations throughout the world as part of a general program to encourage the conduct of fundamental research in seismology. These plans evolved from the recommendations of the Berkner panel on seismology and constitute one element of the U.S. program of research and development to develop an effective nuclear test detection system. The overall U.S. effort, known as Project Vela, is under the direction of the Advanced Research Projects Agency of the Department of Defense. The world-wide standardized seismographic instrument portion of the program is administered by the U.S. Coast and Geodetic Survey.

The new instruments will be capable of recording seismic waves over a wide range of periods (about 0.1 to 100 seconds). They will be accurately calibrated, and the response characteristics will be identical at each station. The intent is to establish a co-operative world-wide seismographic net employing standardized equipment in addition to, or in place of, the existing seismographs. It is expected that such a network will provide new and more quantitative data for studies of seismic activity throughout the world, and for studies of the mechanisms of earthquakes and the propagation of seismic waves.

A panel of American seismologists was appointed by the National Academy of Sciences–National Research Council to advise on the choice of instruments and the basis for selection of the recipients. The panel consisted of the following members:

Perry Byerly, University of California, Berkeley;

Carl Kisslinger, St. Louis University;

Jack Oliver, Columbia University;

Frank Press, California Institute of Technology;

James T. Wilson, University of Michigan, *chairman.*

Recommended Instruments

In considering the most useful types of instruments to recommend, the panel was guided by the following considerations: (i) the instruments should be of types that can be procured without extensive development; (ii) three components should be recorded in every case; (iii) the over-all period response should be such as to cover the most useful part of the spectrum that can be recorded without resorting to equipment of a very special type. These requirements indicate that two sets of three-component instruments are desirable, one short-period set with high magnification, and a relatively long-period set with moderate magnification.

The recommended short-period seismographs consist of variable reluctance seismometers of 1-second period connected by means of step attenuators to galvanometers with periods in the 0.2-to-1.0-second range. The seismograph should have a peak available gain of more than 100,000, although local noise conditions will of necessity control the actual operating gain. The recommended long-period seismographs consist of moving-coil seismometers with periods in the 10-to-30-second range connected to galvanometers with periods of about 100 seconds. The peak available gain will be about 4500; while the operating gain and period response are not yet firm, it is believed that this equipment can be operated with identical characteristics at all stations. Polarized connectors will be used, and both long- and short-period seismographs will have built-in calibrators for daily automatic gain and polarity checks.

Conventional triple-drum photographic paper records will be used. The recording speed will be 60 millimeters per minute for the short-period instruments and 15 or 30 millimeters per minute for the long-period instruments. The timing unit will be controlled by an electronic clock with a rate not to exceed 0.1 second in 4 days to insure adequate time in areas where radio time signals cannot be received every day. The timing unit will provide minute and hour marks, with additional specially coded marks every 6 hours. Synchronous power for driving the recorders will be derived from the electronic clock. A high-quality crystal-controlled radio will be used to detect radio time signals which will be directly recorded on the seismograms.

Selection of Recipients

The first instruments will be made available to those stations not now equipped with instruments of the type recommended by the committee, which indicate an interest in receiving them and have been active and reliable participants in seismic work in the past. Institutions not now actively engaged in seismology which indicate a strong interest in seismological research, and which can demonstrate capability to operate a station on a continuing basis, will also be considered.

It is anticipated that the stations receiving the equipment will, in most cases, provide the vault, pier, building, supplies, and power required to operate the equipment. However, technical assistance, when required, can be provided to aid in the installation, initial calibration, and occasional specialized maintenance of the equipment. The sponsors of the seismological observatory are expected to provide operating personnel, perform ordinary maintenance and, as is the custom among seismologists of the world, make their records available to scientists who request them. The latter is, of course, crucial to the success of the program.

Use of Data

Since one of the purposes of the program is to improve the level of seismic research throughout the world, the stations receiving the equipment will be encouraged to use the data from their equipment to issue improved bulletins and to undertake research programs that were previously not possible.

In addition to the customary individual loan of station records, each station will be expected to make all the records available to researchers throughout the world; for this purpose, the U.S. Coast and Geodetic Survey will act as a central seismogram collection center. Participating stations will be provided with photographic copying facilities and will be requested to send the originals or copies of each seismogram to the Coast and Geodetic Survey. Upon request, these records will be made available by the survey to any interested scientist throughout the world.

The seismographic instrument program is being administered by the Division of Seismology, U.S. Coast and Geodetic Survey, Washington 25, D.C. Requests for copies of the first report of the NAS–NRC Committee on Seismological Stations, as well as all other inquiries pertaining to this program, should be sent to the Coast and Geodetic Survey.

CARL ROMNEY
Air Force Technical Applications Center, Department of Defense, Washington, D.C.

CARL BEYER
Advanced Research Projects Agency, Department of Defense, Washington, D.C.

Grants, Fellowships, and Awards

Alcoholism. A new grant-in-aid program, through which relatively small research grants may be arranged quickly for competent scientists working in the field of alcoholism and related subjects, has been announced by the Scientific Advisory Committee of Licensed Beverage Industries, Inc. The LBI is making this program possible, in response to the growing need for more scientific information as to the extent, causes, and treatments of alcoholism, through a grant of $500,000 extending over a 5-year period.

Grants will be awarded to qualified researchers, including young scientists, in the biological and behavioral sciences who wish to make preliminary or pilot studies for the purpose of raising or clarifying promising hypotheses.

Since this is essentially a "seeding" program, it is expected that grants will range between $2000 and $10,000 and that they will run for 1 year. Renewal of the grant may be considered.

All applications will be reviewed by a Scientific Advisory Committee whose members represent a wide range of relevant disciplines, and applicants will usually be notified of action taken within 90 days. Application forms and detailed information may be obtained by writing to the Scientific Advisory Committee of the Licensed Beverage Industries, Inc., 155 E. 44 St., New York 17, N.Y.

Audiology. Supported by a grant from the National Institute of Neurological Diseases and Blindness, the department of otolaryngology and maxillo-facial surgery, in cooperation with the department of speech pathology and audiology, of the state University of Iowa offers postgraduate training to qualified individuals desiring further preparation for teaching and research careers in medical audiology or investigative work in audition and in the related sensory disease field.

Trainees must have an M.D. or Ph.D. degree or the equivalent, an interest in research, and an outstanding scholastic record. United States citizens or individuals who have filed a declaration of intent to become citizens are eligible for training at a stipend of $4200 per year plus $500 for each dependent. Stipends are tax exempt to the extent of $300 per month for a total of 36 months. Traineeships are for 1 to 3 years, depending upon previous experience and training. For further information write to Dr. Juergen Tonndorf, Department of Otolaryngology, University Hospitals, Iowa City, Iowa.

Medical sciences. The Life Insurance Medical Research Fund is now receiving applications for two types of awards, to be available on 1 July 1961.

Applications for postdoctoral research fellowships will be accepted until *15 October*. Candidates may request support in any field of the medical sciences. Preference is given to those who wish to work on fundamental problems, especially problems related to cardiovascular function or disease. The minimum stipend is $4500, with allowances for dependents and necessary travel.

Grants to institutions in aid of research on cardiovascular problems are also available. Support will be provided for physiological, biochemical, and other basic work broadly related to cardiovascular problems, as well as for clinical research in this field. Further information and application forms may be obtained from the Scientific Director, Life Insurance Medical Research Fund, 345 E. 46 St., New York 17, N.Y. The application deadline is *1 November*.

Study abroad. About 900 Fulbright scholarships for graduate study or predoctoral research in 30 different countries will be available for the 1961–62 academic year. In addition to the Fulbright awards, scholarships for graduate study in 17 Latin-American countries under the Inter-American Cultural Convention are also offered for 1961–62. The Institute of International Education, which administers these student programs for the U.S. Department of State, reports that applications for both types of award are now available.

The Fulbright scholarships cover travel, tuition, books, and maintenance for one academic year. The IACC scholarships cover transportation, tuition, and partial to full maintenance. Both categories of award require United States citizenship at the time of application, a bachelor's degree or its equivalent, and knowledge of the language of the host country. Preference is given to applicants under 35 years of age who have not previously lived or studied abroad.

Applications for Fulbright and IACC scholarships for 1961–62 will be accepted until *1 November*. Requests for applications must be postmarked before *15 October*. Interested students who are now enrolled at a college or university should consult their campus Fulbright advisers. Others may write to the Information and Counseling Division, Institute of International Education, 1 East 67 St., New York 21, N.Y., or to any regional office of the Institute of International Education.

New Journals

Bollettino di Geofisica, Anno I, No. 3, Sept. 1959. Osservatorio Geofisico Sperimentale, Trieste, Italy. $6.

Comité International de Photobiologie, Bull. No. 1, Oct. 1959. B. C. Christensen, Ed. Finsen Memorial Hospital, Copenhagen, Denmark, Irregular.

Bulletin of the International Committee on Urgent Anthropological and Ethnological Research, No. 1, 1958. R. Heine-Geldern, Ed. Secretariat, Reitschulgasse 2, Vienna 1, Austria.

Journal of the Marine Biological Association of India, vol. 1, No. 1, June 1959. P. N. Ganapati, Ed. Marine Fisheries P.O., Mandapam Camp, S. India. Semiannual.

Panminerva Medica, journal of the Italian Medical Association, vol. 1, No. 5, Sept. 1959. T. Oliaro, Ed. Corso Bramante, Torino, Italy. Monthly, $10.

Investigaciones Arqueologicas en Salla, vol. 1, No. 1, Aug. 1959. C. P. Sanginés, Ed. Comision Nacional de la UNESCO and Sociedad Boliviana de Anthropologia. Center of Archaeological Researches in Tiwanaku, Casilla 2325, La Paz, Bolivia.

Journal of Mathematical Physics, Feb. 1960. E. Montroll, Ed. American Institute of Physics, 335 E. 45 St., New York 17, N.Y. Bimonthly.

The Journal of Nuclear Medicine, Jan. 1960. G. E. Thoma, Ed. Samuel N. Turiel and Associates, Chicago 11, Ill. Quarterly. $10.

Journal of Mathematical Analysis and Applications, vol. 1, 1960. Richard Bellman, Ed. Academic Press, New York, N.Y. $16.

Contemporary Physics, vol. 1, No. 1, Oct. 1959. G. R. Noakes, Ed. Taylor and Francis, London, England. $4.

Canadian Veterinary Journal, vol. 1, No. 1, Jan. 1960. Canadian Veterinary Medical Association, Guelph, Ontario, Canada. Monthly. $6.

Communications of the Research Institute for Heavy Chemical Industries, vol. 1, Nos. 1–2 and 3–4, 1959. Kultura Hungarian Book Trading Company, Budapest 62, P.O.B. 149. Irregular. $6 per volume.

Scientists in the News

Staff changes, to become effective 1 July, have been announced by the Public Health Service, Department of Health, Education, and Welfare.

David E. Price, now chief of the Bureau of State Services, will become deputy director of the National Institutes of Health, a position which has been vacant since the retirement of **Cassius J. Van Slyke** last December.

Theodore J. Bauer, present deputy chief of the Bureau of State Services, will succeed Price as bureau chief.

Kenneth M. Endicott, now an associate director of the National Institutes of Health, will be director of the National Cancer Institute, succeeding **John R. Heller**, who has been granted leave by the Public Health Service to accept the presidency of the Memorial Sloan-Kettering Cancer Center in New York City. No successor has as yet been selected for Bauer's present post.

Leon Jacobs, chief of the Laboratory of Parasitic Diseases, National Institute of Allergy and Infectious Diseases, Bethesda, Md., has been awarded a Fulbright fellowship to work at the Wallaceville Animal Research Station in collaboration with scientists of the New Zealand Department of Agriculture. He will be in New Zealand for the next 8 months studying toxoplasmosis, particularly in sheep. Jacobs has also received a Guggenheim Foundation grant that will permit him to return by way of Japan, Southeast Asia, and Europe and to study the parasitic disease problems of those areas. He will be back in the United States early in 1961.

William E. Bennett, professor of physics at Illinois Institute of Technology, will join the University of Buffalo in September.

The Virginia Section of the American Chemical Society has announced that its 1960 Distinguished Service Award will go to **Rodney C. Berry**, state chemist and director of the Division of Chemistry and Foods, Virginia Department of Agriculture.

The top award of $1000 was given to Sister **Mary Hermias Mennemeyer**, chemistry and physics teacher at St. Francis Borgia High School, Washington, Mo., and Sister **Mary Joecile Ksycki**, head of the chemistry department, Notre Dame College, St. Louis, Mo., for their joint entry, "Adventures in Radioactivity for High School Students."

Bausch and Lomb Optical Co. provided a microscope as a prize for the best entry in the field of biology. This, in addition to a $500 award, went to **Carolyn A. Gibson**, biology teacher at North Hills High School, Pittsburgh, for her entry, "Cancer Research Team of North Hills High School Biology Students."

The STAR program is sponsored by the NSTA, a department of the National Education Association, under a grant from the National Cancer Institute of the National Institutes of Health. The awards are designed to stimulate and recognize promising new practices in high-school science teaching, grades 7 to 12.

Thomas R. O'Meara, Hughes Aircraft Company electrical engineer, has received the first Dr. William G. Tuller Memorial Award of the Institute of Radio Engineers "in recognition of the most outstanding technical paper dealing with electrical component parts published in professional journals in 1959."

Ivan C. Berlien joined the faculty of the University of Miami School of Medicine on 1 May as associate professor of psychiatry and director of psychiatric research. He has been a practicing psychiatrist in Detroit and assistant professor of psychiatry at the Wayne State College of Medicine.

Henry Taube, professor of chemistry at the University of Chicago, has been selected to receive the Harrison Howe Award of the Rochester Section of the American Chemical Society. He is being honored for his contributions to inorganic chemistry, particularly with respect to the reactions of ions in solution. Taube will deliver the Harrison Howe lecture in Rochester early in November.

Gustave J. Dammin, professor of pathology, Harvard Medical School, has been elected president of the tri-service Armed Forces Epidemiological Board. He succeeds **Thomas Francis**, chairman of the department of epidemiology, School of Public Health, University of Michigan, who had served as president of the AFEB since January 1958. Members of the board are appointed by the Secretary of the Army, and the members elect their own president.

Martin D. Davis, visiting associate professor of mathematics at New York University, has been appointed associate professor of mathematics at the Yeshiva University Graduate School of Mathematical Sciences.

Harry T. Stinson, Jr., has been appointed head of the department of genetics at the Connecticut Agricultural Experiment Station, New Haven. He succeeds **Donald F. Jones**, who will retire on 30 June after 45 years at the station. Stinson began his career at the station in 1952.

Hans Neurath, professor and executive officer, department of biochemistry, University of Washington (Seattle), was at the University of Redlands for 3 days in May as the Science Visitor for 1960. A gift from the Nutri-Bio Corporation of Los Angeles supported Neurath's visit.

B. S. Schweigert has been appointed professor and head of the department of food science at Michigan State University, East Lansing. He was formerly director of research and education for the American Meat Institute Foundation and associate professor of biochemistry at the University of Chicago.

James E. Canright, associate professor of botany at Indiana University, has been appointed a Guggenheim fellow for the year 1960–61. He will conduct a research program on primitive families of flowering plants (Ranales) in Malaya and Indonesia. His major centers of operation in the course of this study will be the Botanic Gardens of Indonesia (at Bogor, Java) and the Singapore Botanic Gardens.

Calvin W. Woodruff, professor of pediatrics at Vanderbilt University School of Medicine, will resign on 30 June to accept appointment as professor of pediatrics and chairman of the department at the American University of Beirut (Lebanon). He will assume his new duties on 1 August.

Heinz G. F. Wilsdorf, head of the physics of metals branch of the Franklin Institute Laboratories, has been named technical director of solid-state sciences. In addition to the physics of metals branch, he will also direct the metallurgy branch and the magnetics and semiconductors branch.

Book Reviews

Advances in Space Science. vol. 1, *1959*. Frederick I. Orday, III, Ed. Academic Press, New York, 1959. xii + 412 pp. Illus. $12.

This book is the first volume in a new series of the *Advances* that have proved to be extremely useful in keeping scientists and engineers abreast of research and development. In reviewing this book, perhaps it is appropriate to give first a definition of the subject, space science (or astronautics). The view that emerges from this collection of articles is that space science is an extremely broad subject encompassing selected aspects of many basic sciences. In particular, it comprises those aspects of physics, chemistry, mathematics, biology, geology, and astronomy, as well as the engineering disciplines, which are grouped together and coordinated for the purpose of the study and exploration of the universe beyond the confines of the earth's atmosphere. The scope of the subject is well illustrated by the topics covered in this volume.

The first chapter, "Interplanetary rocket trajectories" (D. F. Lawden), is concerned with the mathematical problem of determining the optimal track for sending a rocket vehicle from a launching point on the surface of one planet to a designated point on the surface of another planet. The material, treated from the sophisticated standpoint of a calculus of variations problem of the Mayer type, discusses many interesting cases in detail.

In the next chapter, "Interplanetary communications" (J. G. Pierce and C. C. Cutler), the authors discuss many well known scientific and engineering laws of communication as well as recent advances which might lead to communication systems that are needed for transmitting data over lunar, planetary, and stellar distances.

The environment of space, power requirements of space vehicles, primary power sources, conversion techniques, and complete power systems are discussed in "Power supplies for orbital and space vehicles" (J. H. Hughes). Many of the topics touched on here are clearly in their infancy; despite the difficulty inherent in a subject that ranges over so many disciplines, the author makes admirable attempts at extrapolations.

In "Manned space cabin systems" (E. B. Colletti), the author first reviews the entire subject for both the interested nonspecialist and the specialist. Topics discussed include the human factor, flight support systems, and present and future manned systems. This review contains a very interesting commentary on the motivating forces in human beings, particularly as they are related to space exploration. This provides grounds for understanding the man-in-space programs and points clearly to the need for cooperation between design engineers and life scientists to accomplish the exploration of space.

The next chapter, "Radiation and man in space" (H. T. Shaeffer), contains an evaluation of the ionizing radiations in space in terms of the possible exposure hazards to man. Included are very detailed discussions of the primary cosmic radiation and its transition in the atmosphere, time variations of cosmic ray intensity, high-intensity radiation in fuels in space, and finally, a discussion of the avenues of radiobiological experimentation which must be followed to fill the many gaps in our present knowledge.

"Nutrition and space flight" (G. Fisher) is concerned with space feeding; this subject has many aspects, some of which are but extrapolations of air feeding techniques. Here again it is clear that an understanding of all phases of life processes is essential to the subject.

An appendix (by H. H. Koelle) contains a helpful decimal classification system, adopted by the International Astronautical Federation, for filing references, technical papers, and other material.

Each chapter contains an extensive list of references comprised mainly of articles on space science which have been published since 1955. The advances in the subject represented by these extensive references are truly spectacular.

Because of the tremendous scope of this subject as well as the breadth of knowledge related to space science and, at the same time, the depth of knowledge required to make new contributions to the specific branches of science represented, we do not have men who can truly be called space scientists. Alas, even Leonardo da Vinci would be overwhelmed! Instead, the scientists who function in this field must be competent specialists who have a moderately complete knowledge of the subject as a whole. *Advances in Space Science* should be extremely helpful to specialists for securing information concerning recent contributions made in their specialty to astronautics as well as for obtaining a general picture of the subject as a whole.

The challenge of space exploration and study should excite the imagination of all adventurous and inquisitive men. Perhaps it will be an all-consuming outlet for the excessive energies and ambitions of the human species and, thus, serve as a substitute for war. In the last analysis, this might well be the greatest advance associated with "advances in space science" from the standpoint of mankind as a whole.

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The Study of Elementary Particles by the Photographic Method. An account of the principal techniques and discoveries illustrated by an atlas of photomicrographs. C. F. Powell, P. H. Fowler, and D. H. Perkins. Pergamon Press, New York, 1959. xvi + 669 pp. Illus. $40.

C. F. Powell was awarded the 1950 Nobel prize in physics for his development and application of the nuclear emulsion technique as a quantitative tool for studying nuclear processes. He now has collaborated with two of his colleagues at the University of Bristol

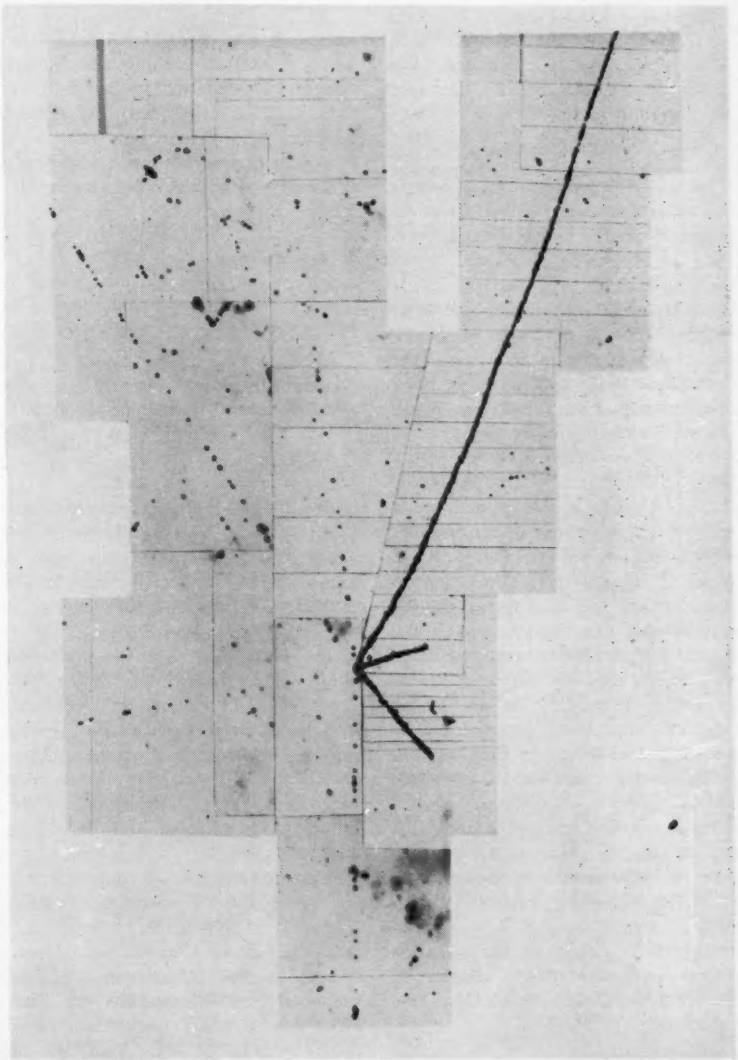
in the production of an exceptionally interesting, attractive, and distinguished record of this technique and its influence on an exciting period in the history of nuclear physics. This period began auspiciously in 1945 with the development of improved emulsions that permitted observation of the tracks of all cosmic ray particles, including electrons and mesons. The end of the period was reached with the production and detection of antiprotons in the laboratory. The contribution of the nuclear emulsion technique to this triumph is exemplified by the accompanying photograph, taken in 1956, showing the annihilation of an antiproton in an emulsion.

At the end of this historical period, probably all of the family of elementary particles—electrons, mesons, nucleons, and hyperons—either had been discovered, or their existence had been anticipated. Therefore, this superior book is timely, and it should play an important role for many future years as a convenient reference volume for the specialist and as an excellent introduction for the nonspecialist.

Less than one third of the book is devoted to the subject of the emulsions: preparation and composition, methods of measurement, and identification of particles. One half deals with the discovery of and data concerning specific elementary particles, a subject that serves as the central theme and integrates the discussions of technique, photographs, and history. By emphasizing this theme throughout and describing all the pertinent experimental and theoretical principles, the authors have made a complete and absorbing story of elementary particles and the part played by emulsions. In the remainder of the book, the authors consider the tracks of nuclear disintegrations produced by elementary particles at high energies as well as the tracks of the heavy nuclei of cosmic radiations. A striking example of the latter is a carbon nucleus plowing into an emulsion with an energy of 20,000 billion electron volts. This book shows how to produce and analyze such tracks, and it contains 187 photomicrographs as examples.

There are 16 separate sections, each with good references and illustrations. The subheadings of one of these sections entitled π-mesons should help describe the thoroughness and philosophy underlying the presentation: discovery of the π-meson, decay of the π-meson, nuclear capture of negative π-mesons, production of π-mesons in nuclear collisions, the neutral π-meson, the masses of charged and neutral π-mesons, the mean lifetimes of charged and neutral π-mesons, spin and parity of the π-mesons, and the breakdown of parity in weak interactions.

Unfortunately, the enormous effort required to prepare and, indeed, to print this book almost of necessity resulted in some drawbacks, most of which are minor. For example, there are references to technical details such as Lami's theorem and the L- and σ-mesons, which are not listed in the index, but which can be elucidated after some considerable thumbing of pages to find the place where they are described in detail. Literature references to a few technical papers are not given, although they are cited as source materials. The descriptions of emulsion processing are a little incomplete. In addition, the principal audience for which this book was intended—the physics graduate student and the more senior college students—will find it difficult to own this invaluable source book because of its unfortunate price:



An example of the annihilation of an antiproton (1956). The antiproton entered the emulsion at the upper right and disintegrated into two protons (dense tracks) and four charged π-mesons (light tracks). The total visible release of energy was 1.4 billion electron volts.

$40. However, since physics libraries will be required to purchase copies, this book, which is the excellent combination of a cookbook, reference-record, and nuclear history-account, will, nevertheless, prove to be available and to be very readable, useful, and inviting to the neophyte physicist.

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Strahlenbiologie, Strahlentherapie, Nuklearmedizin, und Krebsforschung, Ergebnisse 1952–1959. H. R. Schinz, H. Holthusen, H. Langendorff, B. Rajewsky, and G. Schubert, Eds. Thieme, Stuttgart, 1959 (order from Intercontinental Medical Book Corp., New York). 998 pp. Illus. $65.50.

In the 16 chapters of this volume, 19 experts present and discuss the progress made between 1952 and 1958 in the fields mentioned in the book title. The first chapter (by H. Sommermeyer), on the historical development of the target theory, emphasizes the applications made since 1946. This is followed by four chapters on radiation genetics in bacteriophages (by W. Harm), microorganisms (by R. W. Kaplan), *Drosophila* (by H. Fritz-Niggli), and mammals (by H. Nachtsheim). Dosage problems and megavolt irradiation techniques are discussed in two chapters (by W. Pohlit and R. Wideröe, respectively). Three chapters are devoted to clinical-therapeutical applications, experiences, and results obtained when different equipment and methods are used in different situations. Of special interest is the chapter on rotation therapy and grid therapy, as well as the chapter (by Hug) on the acute general reactions to total-body and partial-body irradiations. Progress in the application and use of isotopes is analyzed in two chapters: a critical review of treatments with radioisotopes and a report on I^{131} diagnostic procedures in thyroid diseases. A chapter on the effects of drugs on the radiation damaged organism and a chapter on radiomimetic substances complete the collection.

The book is stimulating reading for every one working in the mentioned fields and is of special interest insofar as it reflects, in the broadest sense, the European approaches and attitudes towards radiation biology and radiation medicine. Written by German and Swiss scientists, it shows their way of analyzing and interpreting data, with the goal of giving stimulation and presenting conclusions which may inspire and promote future experiments and research.

The simplest way to give an idea of the level, value, and importance of the volume is to compare it with the well known Annual Review Series covering such fields as nuclear medicine, physiology, and biochemistry. In doing this, it becomes evident that the book compares favorably with these volumes. This is all the more remarkable since the authors had to cover in a limited space nearly 7 years of progress. Much more impressive are the well written presentation and the clever and experienced selection of the numerous references. For a long time this book will be an important reference work for study, lecture, and research.

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General Climatology. Howard J. Critchfield. Prentice-Hall, Englewood Cliffs, N.J., 1960. xiii + 465 pp. Illus. $7.95.

Breadth rather than depth characterizes this book. This is intentional because it is evident that the book is aimed at the nonspecialist student. As the text for an elementary course, it will fulfill its purpose.

The book deals with weather and climate. One part is devoted to a description of the climates of the world. The use of meteorological and climatological knowledge in human activities is related. Also included in its wide range are weather forecasting and the influences of weather on vegetation and soils.

In some respects one could call this an anthology; it contains nothing original, and it is evident that the author has not gone much beyond secondary sources. About two-thirds of the nearly 200 illustrations are from other works. Many came from other texts: volumes of *The Yearbook of Agriculture* and other government publications.

Critchfield has an easy style, and the well-produced book is completely free of technical jargon. But I hope no one will be misled by this smooth approach and conclude that answers in the fields of atmospheric sciences are easy to come by.

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Progress in Inorganic Chemistry, vol. 1. F. A. Cotton, Ed. Interscience, New York, 1959. ix + 566 pp. $14.50.

According to the preface statement by the editor, this volume initiates a new series of publications on modern inorganic chemistry; it is intended that the volumes appear annually, that the articles be written by leading researchers in the particular field, and that they be comprehensible, but not necessarily readily so, to a competent research worker at the Ph.D. level in some branch of inorganic chemistry, not necessarily the one under discussion.

It is further intended that the author be given the responsibility and the privilege of presenting a scholarly and accurate account of his subject without feeling that he needs to oversimplify and that he be regarded as best qualified to determine the style, length, and general nature of the treatment of his subject. Articles are to be published in English, German, and French.

The first volume contains seven articles: "Cyclopentadienyl and arene metal compounds" (G. Wilkinson and F. A. Cotton); "Interstitial compounds of graphite" (G. R. Henning); "Über Schwefel-Stickstoff-Verbindugen" (Margot Becke-Goehring); "Metal-ammonia solutions" (W. L. Jolly); "Isocyanide complexes of metals" (L. Malatesta); "The effects of inner orbital splitting on the thermodynamic properties of transition metal compounds and coordination complexes" (P. George and D. S. McClure); and "The structure and properties of mixed metal oxides" (R. Ward).

This new series on the progress in inorganic chemistry appears to have gotten off to a good start, and forthcoming volumes, if they maintain the high ideals that have been set, should prove to be extremely valuable in presenting the rapidly developing mass of information in this branch of chemistry.

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New Books

Biological and Medical Sciences

Balinsky, B. I. *An Introduction to Embryology*. Saunders, Philadelphia, 1960. 576 pp.

Benson, Otis O., Jr., and Hubertus Strughold, Eds. *Physics and Medicine of the Atmosphere and Space*. Wiley, New York, 1960. 663 pp. $12.50. Proceedings of the second international symposium held at San Antonio, Texas, 10–12 November 1958, and arranged by the Southwest Research Institute.

Boyer, Paul D., Henry Lardy, Karl Myrvack, Eds. *The Enzymes*. vol. 2, *Purine and Pyrimidine Nucleotides and Phosphagens. Prosthetic Groups and Cofactors* (part A). Academic Press, New York, 1960. 493 pp. $16. Contributors to this volume include H. Beinert, R. M. Bock, A. E. Braunstein, C. E. Cardini, A. H. Ennor, E. P. Kennedy, W. E. Knox, L. F. Leloir, D. E. Metzler, J. F. Morrison, J. C. Rabinowitz, and M. F. Utter. The topics covered in this volume will be continued in volume 3.

Bruner, H. D., Ed. *Methods in Medical Research*. vol. 8. Year Book, Chicago, 1960. 382 pp. $9.75. Contents: "Life history of the Erythrocyte," "Measurement of responses of involuntary muscle," and "Peripheral blood flow measurement."

Causey, Gilbert. *The Cell of Schwann*. Livingston, Edinburgh; Williams and Wilkins, Baltimore, Md., 1960. 131 pp. $4.75.

Chupp, Charles, and Arden F. Sherf. *Vegetable Diseases and Their Control*. Ronald, New York, 1960. 698 pp. $12. In the preface the authors state that this is an attempt to present an organized account, suitable for use by commercial growers and by others, of the more than 30,000 literature reference (in many languages) concerned with the diseases of vegetables and with the control of these diseases.

Conn, H. J., *et al. Staining Procedures Used by the Biological Stain Commission*. William and Wilkins, Baltimore, Md., ed. 2, 1960. 301 pp. $5. Published under the auspices of the Biological Stain Commission (University of Rochester Medical Center), this publication is intended to represent staining methods used in microtechnique in the laboratories of the commission members.

Fink, Bruce. *The Lichen Flora of the United States*. Univ. of Michigan Press, Ann Arbor, 1960 (second printing). 438 pp. $12.50. In a foreword prepared for this printing, Alexander H. Smith comments that the book has "filled a very great need for the naturalists of North America as well as for those living abroad. . . . It is evident to all students of the plant sciences that this manual, published in 1935, is out of date in many respects. However, since the more recent work has not been brought together in manual form, [it] is still a foundation stone for the study of lichens in this country."

Florkin, Marcel, and Howard S. Mason, Eds. *Comparative Biochemistry*. A comprehensive treatise. vol. 2, *Free Energy and Biological Function*. Academic Press, New York, 1960. 704 pp. $20. The contents of this volume include free energy and biosynthesis of phosphates, utilization of free energy for the biosynthesis of saccharides, comparative biochemistry of free energy utilization for the biosynthesis of peptides and proteins, ammonia metabolism and urea biosynthesis, muscular contraction, other mechanisms producing movements, active transport, balance of water, electrolytes, and nonelectrolytes, the mechanisms of osmoregulation, nerve conduction and electrical discharge, and bioluminescence.

Lederer, E., Ed. *Chromatographie*. En chimie organique an et biologique. vol. 2, *Applications en Chimie Biologique*. Masson, Paris, 1960. 890 pp.

Parkes, A. S., and Audrey U. Smith, Eds. *Recent Research in Freezing and Drying*. Thomas, Springfield, Ill., 1960. 327 pp. $13.75. Proceedings of the second International Symposium on Freezing and Drying, 1958.

Rensch, Bernhard. *Evolution above the Species Level*. Columbia Univ. Press, New York, 1960. 436 pp. $10. A translation of the second edition of *Neuere Probleme der Abstammungslehre* (1954).

Reyniers, James A., *et al. Germfree Life Studies*. No. 3. Univ. of Notre Dame Press, Notre Dame, Ind., 1960. This volume, a publication of the Lobund Institute, contains a résumé of the studies by R. W. Glaser (by N. R. Stoll); "A survey of germfree animals: the white Wyandotte bantam and white Leghorn chicken"; "Parasitological survey of Lobund germfree animals"; and "Rearing germfree turkeys."

Rytand, David A., and William P. Creger, Eds. *Annual Review of Medicine*. vol. 11. Annual Reviews, Palo Alto, Calif., 1960, 460 pp. $7.

Steel, Robert G. D., and James H. Torrie. *Principles and Procedures of Statistics*. McGraw-Hill, New York, 1960. 497 pp. $10.50.

Mathematics, Physical Sciences, and Engineering

Apostle, H. G. *A Survey of Basic Mathematics*. Little, Brown, Boston, Mass., 1960. 479 pp.

Azaroff, Leonid V. *Introduction to Solids*. McGraw-Hill, New York, 1960. 474 pp. $9.50.

Bates, Robert L. *Geology of the Industrial Rocks and Minerals*. Harper, New York, 1960. 453 pp. $10.

Brady, Wray G., and Maynard J. Mansfield. *Calculus*. Little, Brown, Boston, 1960. 463 pp.

Condon, F. E., and Herbert Meislich. *Introduction to Organic Chemistry*. Holt, Rinehart and Winston, New York, 1960. 859 pp. $10.50.

Darmois, Eugène, and Geneviève Darmois. *Electrochimie Théorique*. Masson, Paris, 1960. 239 pp. NF. 39.

Day, Allan R., and Madeleine M. Joullie. *Organic Chemistry*. Van Nostrand, New York, 1960. 870 pp. $9.50.

Sackheim, George I. *Physics Calculations*. Macmillan, New York, 1960. 267 pp. Paper, $3.50. Intended to show the beginning physics student the relationship between the principles of physics and their application in many different types of problems.

Schwartz, Seymour, Ed. *Selected Semiconductor Circuits Handbook*. Wiley, New York, 1960. xiv + 11 parts. $12. Provides the electronic engineer with more than 150 semiconductor circuits. Parts 2 through 10 were originally published by the Bureau of Ships as *A Handbook of Semiconductor Circuits*.

Shames, Irving H. *Engineering Mechanics Dynamics*. Prentice-Hall, Englewood Cliffs, N.J., 1960. 408 pp. $6.75.

Strahler, Arthur N. *Physical Georgraphy*. Wiley, New York, ed. 2, 1960. 544 pp. $7.50.

Social Sciences

De Laguna, Frederica, Ed. *Selected Papers from the American Anthropologist, 1888–1920*. Published for the American Anthropological Association by Row, Peterson, Evanston, Ill., 1960. 940 pp. $8. This book, addressed primarily to the scientifically oriented public, seniors and beginning graduate students marks the 70th anniversary of the founding of the *American Anthropologist* and is intended to represent the interests and accomplishments in American anthropology from the time the journal was established through World War I. A. I. Hallowell has contributed an essay on the beginnings of anthropology in America and the editor has added a selected bibliography.

Glover, Edward. *The Roots of Crime*. International Universities Press, New York, 1960. 435 pp. $7.50. Volume 2 of *Selected Papers on Psychoanalysis*.

Goldschmidt, Walter. *Exploring the Ways of Mankind*. Holt, Rinehart and Winston, New York, 1960. A revised and expanded edition of *Readings in the Ways of Mankind* (1957).

Gurin, Gerald, Joseph Veroff, Shelia Field. *Americans View Their Mental Health*. Basic Books, New York, 1960. 479 pp. $7.50. This is the fourth volume in the series currently being published under the auspices of the Joint Commission on Mental Illness and Health. Findings in the following areas of human behavior are discussed: the degree of satisfaction with the marital relationship, contentment or frustration on the job, attitudes toward rearing children, the relationship between religious belief and mental health, the feelings of unmarried persons about their status, the relationship between educational attainment and self-esteem, and the ways in which people attempt to solve their emotional problems.

Jackson, Don D., Ed. *The Etiology of Schizophrenia*. Basic Books, New York, 1960. 456 pp. $7.50.

Plunkett, Richard J., and John E. Gordon. *Epidemiology and Mental Illness*. Basic Books, New York, 1960. 143 pp. $2.75. Monograph No. 6 in the series published for the Joint Commission on Mental Illness and Health.

Waelder, Robert. *Basic Theory of Psychoanalysis*. International Universities Press, New York, 1960. 286 pp. $5.

Reports

Diurnal Cycles and Cannibalism in Planaria

Abstract. *Dugesia tigrina* attacks *Cura foremani* under certain circumstances. The length of fast prior to the attack and diurnal rhythms are involved in evoking such behavior.

The immature *Dugesia tigrina* sometimes attacks the planarian *Cura foremani* (*1*). Qualitative observations suggested a diurnal variation in likelihood of attack. Since neither this particular attacking behavior, nor its diurnal variation, has been previously reported, more systematic studies were undertaken.

When *C. foremani* and *D. tigrina* were removed from the dimly lighted conditions of maintenance in our laboratory, placed in a dish containing fresh spring water and illuminated by an overhead fluorescent light, they glided about in the dish. If a *D. tigrina* makes head contact with a *C. foremani* in the course of this gliding about, the former makes a slight withdrawal response. In contacts resulting in attack this withdrawal response is rapidly followed by a quick, snakelike lunge by *D. tigrina*. This results in an adhesive attachment of the *D. tigrina*'s head to the mid-dorsal surface of the *C. foremani* while the *D. tigrina*'s tail is anchored by adhesive attachment to the dish floor (Fig. 1*b*). The *D. tigrina* then contracts lengthwise and "hauls in" its prey (Fig. 1*c*) which, depending on its size relative to its attacker's, and the vigor of the attack, may escape.

On some occasions the attacks are "half-hearted"; on others, savage and persistent. If the *D. tigrina* manages to hang on, it works its head to a more rostral attachment (Fig. 1*d*), then loops a tight coil about the *C. foremani* (Fig. 1*e*). From this position the *D. tigrina* uses its pharynx to tear out and ingest pieces (visible inside its digestive cavity) from its captive. *Cura foremani* was not observed to attack *D. tigrina* or another *C. foremani* although it readily attacks larger active prey such as mosquito wrigglers and smaller brine shrimp. *Dugesia tigrina* adheres to glass surfaces more tenaciously than *C. foremani*, indicating more powerful adhesive organs (*2*) and an advantage in combat, but not why *C. foremani* does not initiate attacks on *D. tigrina*.

For quantifying such attack behavior the following procedure was adopted. A *D. tigrina* (about 14 mm) was removed by random selection from a stock population of *D. tigrina* and placed in a bowl containing fresh water and approximately 25 specimens of *C. foremani*, ranging in size from 5 to 16 mm in length; the size distribution of the *C. foremani* population was maintained approximately constant in all tests. The bowl was observed on a white background under an overhead light. Each contact of *D. tigrina* with *C. foremani* was scored according to the three possibilities: (i) no attack, (ii) unsuccessful attack, (iii) successful attack. An attack was considered successful if, following it, ingested fragments of *C. foremani* were observed in the *D. tigrina*. When the digestive cavity of a *D. tigrina* was about half filled, that individual was removed and scored no more, in order to avoid satiation effects. If after 15 to 25 contacts the digestive cavity of the *D. tigrina* was still less than half filled, it was removed and scored no further. Once a *D. tigrina* had been used it was not used again.

When the number of contacts resulting in no attack is denoted as n_1, an unsuccessful attack as n_2, and a successful attack as n_3, the total number of contacts by the *D. tigrina* will be $n = n_1 + n_2 + n_3$. The "cannibalistic attack score," s, for an individual *D. tigrina* at its time of testing is defined as

$$s = (0 \cdot n_1/n) + (1 \cdot n_2/n) + (3 \cdot n_3/n) \quad (1)$$

The score s is a measure of the attack behavior that is, to a first approximation, independent of the simple locomotor activity per se of either organism at the time of assessment. Increased locomotor activity of the *D. tigrina* will increase the number of contacts per unit time but need not increase s. From Eq. 1 it is clear that $0 \leq s \leq 3$ for any worm. Because a *D. tigrina* is not used again once it has been scored, each s is an independent measurement.

Since, in pilot studies, no attack behavior was ever exhibited by a *D. tigrina* recently fed to satiation, scoring was not conducted on a *D. tigrina* fasted less than 45 hours. At the outset of the fast period every *D. tigrina* was fed to satiation on raw beef liver. The laboratory temperature was maintained at 70°F during the period in question.

Table 1 gives s scores for the various *D. tigrina* specimens grouped according to length of fast and time of day of scoring. Measurements after 6 P.M. and before 6 A.M. are classified as "night," although most of them fall between 10 P.M. and 6 A.M. Most day measurements fall between noon and 6 P.M., but any after 6 A.M. and before 6 P.M. are classified as "day."

A median test (*3*) comparison of night and day scores of those organisms fasted more than 98 hours gives $P < .001$, night being greater than day. Neither night nor day scores of animals fasted less than 90 hours differs significantly from zero. A comparison between day scores of the long- and short-fast groups gives $P < .005$, the longer fasted being greater. Night scores of the longer fasted are greater than those of the short fasted with $P < .0015$. Hence, at least two factors, length of fast and time of day, are determiners of the attack behavior of *D. tigrina*. The mechanisms of mediation in the present case are unknown. The effect of fasting and feeding on this behavior suggests involvement of some "hunger drive" mechanism.

The diurnal effect is not related to contemporary changes in temperature

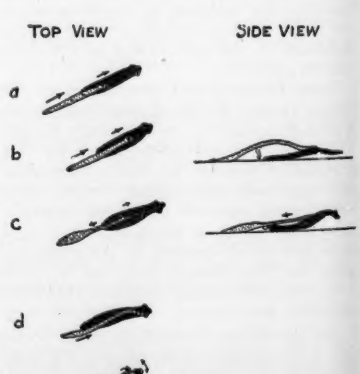

Fig. 1. *Dugesia tigrina* (stippled) attacking *Cura foremina* (dark).

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

Table 1. Frequency distribution of attack scores for *D. tigrina* as a function of length of fast and time of day tested.

Score interval	Length of fast: 45 to 90 hr, Day	45 to 90 hr, Night	98 hr, Day	98 hr, Night
$s = 0$	6	6	5	2
$0 < s \leq 0.1$	0	2	3	1
$0.1 < s \leq 0.4$	0	0	6	2
$0.4 < s \leq 0.6$	0	0	2	4
$0.6 < s \leq 0.8$	0	0	1	2
$0.8 < s \leq 1.0$	0	0	1	8
$1.0 < s \leq 1.5$	0	0	0	3
$1.5 < s \leq 3.0$	0	0	0	6

or illumination. Available facilities did not permit conclusion in regard to the "driven oscillator" model (*4*) as the means of synchronization to the solar day. Other species (*5*) exhibit similar diurnal rhythms in behavior (*6*).

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References and Notes

1. Species supplied as *D. dorotocephala* by Carolina Biological Supply Co., Elon College, N.C., but although black pigmented do not otherwise resemble these and have been identified as *C. foremani* by C. A. Miller and W. H. Johnson, *Ann. N.Y. Acad. Sci.* **77**, 87 (1959).
2. L. H. Hyman, *The Invertebrates* (McGraw-Hill, New York, 1951), vol. 2, p. 80.
3. A. M. Mood, *Introduction to the Theory of Statistics* (McGraw-Hill, New York, 1950), p. 395.
4. C. S. Pittendrigh, *et al., Proc. Natl. Acad. Sci. U.S.* **44**, 965 (1958); V. G. Bruce and C. S. Pittendrigh, *Am. Naturalist* **92**, 295 (1958).
5. G. P. Wells, *Symp. Soc. Exptl. Biol.* No. 4, 127 (1950); F. M. Baldwin, *J. Animal Behavior* **7**, 187 (1917); J. Arbit, *Science* **126**, 654 (1957); F. A. Brown, Jr., *et al., J. Exptl. Zool.* **123**, 29 (1953); *Sci. American* **190**, 34 (1954).
6. I wish to acknowledge the assistance of Mr. David Schucker in conducting these observations.

15 March 1960

New Quaternary Ammonium Compounds with Adrenomimetic Action

Abstract. Quaternary salts of two triesters of *p*-dimethylaminothiophenol and phosphoric acid or thiophosphoric acid have effects similar to epinephrine on blood pressure, heart rate, and the nictitating membrane of the anesthetized cat. Two analogous compounds derived from phenol are depressor. None is a potent anticholinesterase. Further investigation is desirable because of the possibility of a relatively specific action on sympathetic ganglia.

In the course of a study of anticholinesterases, certain triaryl phosphate esters bearing quaternary ammonium groups were synthesized (*1*) which failed to show the expected activity. For four of these, the code number, structure, and relative activity in vitro as cholinesterase inhibitors compared to neostigmine are: CP46, $(RO)_3P{=}S$, 1.8; CP99, $(RS)_3P{=}O$, 0.53; CP98, $(RS)_3P{=}S$, 3.8; CP27, $(R'O)_3P{=}S$, 0.25; neostigmine 100, where

$$R = \text{I} \cdot (CH_3)_3\overset{+}{N}\langle\bigcirc\rangle -$$

and R' is the corresponding *meta* isomer of R. This is in marked contrast to related quaternary ammonium phosphate esters, such as the dialkoxyphosphinyl esters of *m*-dimethylaminophenol methiodide (phosphostigmines) (*2*), which are potent inhibitors of cholinesterase. The low activity of compound 27 indicates that this is not a question of meta as against para orientation. All of these compounds were tested on the anesthetized cat for effects on blood pressure, respiration, heart rate, and the nictitating membrane.

Animals were anesthetized with Dial. Blood pressure was recorded with the Sanborn electromanometer; respiration, with a Krogh spirometer recycled four times per minute, from which rate and minute volume could be read; heart rate was recorded with a Thorp counter integrated over a 10-second interval; and contractions of the nictitating membrane, with an isotonic lever. All injections were given into the femoral vein. Test doses of acetylcholine (1 μg/kg) and of epinephrine (1 to 8 μg/kg) were given before and after injection of the experimental compound.

None of these substances induced muscle fasciculation or the typical profound muscarinic effects characteristic of systemically administered anticholinesterases. Compounds 27 and 46 were found to be moderately long-acting depressors. Compound 27 has been studied clinically in peripheral vascular disease as a vasodilator (*3*). Its mechanism of action is in doubt and does not fall into any obvious classification. Compounds 98 and 99, on the other hand, were pressor and their actions were as follows: compound 99 showed a minimal effect on the blood pressure at 0.1 mg per kg which consisted in a slight and transient rise or fall or biphasic response. Similar effects were seen with epinephrine at 1 μg/kg. At higher doses of compound 99 the blood pressure was consistently elevated, sometimes showing a bimodal curve as illustrated in Fig. 1. The onset and duration of the pressor action appeared to be the same for compound 99 and epinephrine at equally pressor doses. The heart rate did not change markedly and moved in the same direction as after test doses of epinephrine. In small to moderate doses, compound 99 caused a transient stimulation of respiratory minute volume without alteration in rate. At high doses, 6 to 12 mg/kg, the animals died as a result of immediate respiratory arrest. Contraction of the nictitating membrane occurred at dosage levels showing effects on blood pressure, and the two effects had the same duration. A fall in blood pressure was observed with both compound 99 and epinephrine in animals previously given 15 mg of dibenamine per kilogram intravenously in three divided doses. Duration was comparable to that of the pressor effect before dibenamine.

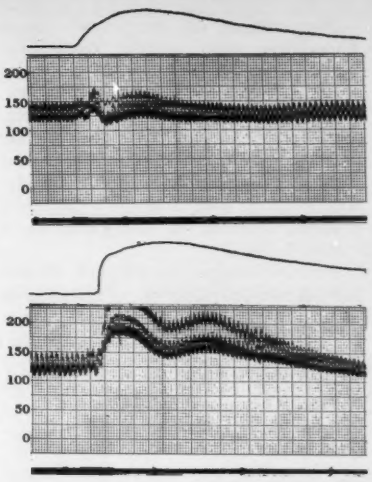

Fig. 1. Female cat, 2.7 kg, Dial anesthesia. From top to bottom: isotonic contraction of the nictitating membrane, blood pressure in millimeters of mercury, time in minutes. At the signal in the upper tracing epinephrine (0.004 mg/kg) was injected. At the signal in the lower tracing compound 99 (2 mg/kg) was injected. Drugs were given intravenously.

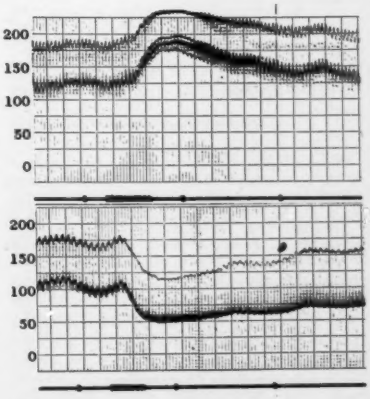

Fig. 2. Female cat, 3.2 kg, Dial anesthesia. From top to bottom: blood pressure in millimeters of mercury, time in minutes. At each signal compound 98 (5.3 mg/kg) was injected. Between the upper and lower tracings three doses of dibenamine (5 mg/kg) were given. Drugs were given intravenously.

The actions of compound 98 on heart rate, blood pressure, respiration, and nictitating membrane responses were, in general, the same as for compound 99, except that minimal effects were first seen at about 0.5 to 1 mg/kg, and death from respiratory arrest occurred at from 10 to 20 mg/kg. The effect of dibenamine on the blood pressure response to compound 98 is shown in Fig. 2.

Neither compounds 98 nor 99 exhibited tachyphylaxis or potentiation as a result of repeated doses given over a period of a few hours, and neither modified the control response to test doses of epinephrine or acetylcholine.

The mechanism of action of compounds 98 and 99 remains to be determined, but certain presumptions may be made on the evidence available about the effects observed in the cat. Since they are quaternary ammonium compounds, they are in all probability excluded from the central nervous system. For the same reason, action on sympathetic nerve endings is unlikely. Hence their pressor effect would appear to be due to a nicotinic action on autonomic ganglia. A relative predilection for sympathetic ganglia is suggested by the absence of marked parasympathetic phenomena. It is of interest that there was no evidence of depression of ganglia after repeated doses. Rapid destruction of these phosphate esters seems likely because of their short duration of action and lack of cumulative effects. The pharmacologic actions observed do not appear to have been reported previously among phosphate esters and specificity of any degree for sympathetic ganglia is rare. Further study of this class of compounds would therefore seem to be indicated.

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References and Notes

1. The compounds described were prepared in these laboratories by Dr. H. M. Fitch from the appropriate phenols and chlorophosphates, using conventional methods.
2. A. S. V. Burgen and F. Hobbiger, *Brit. J. Pharmacol.* **6**, 593 (1951).
3. O. A. Rose and A. Ebel, *J. Am. Geriatrics Soc.* **4**, 142 (1956).

4 March 1960

Self-Absorption Correction for Carbon-14 Assay

R. W. Hendler has proposed a method to derive self-absorption corrections for carbon-14 assay [*Science* **130**, 772 (1959)]. His method consists in the determination of the apparent specific activities for various weights of the radioactive compound. An apparent specific activity at a convenient arbitrary weight is taken as the reference activity, and the ratio of the apparent specific activities at any weight to the reference activity is designated as the conversion (or correction) factor F. By multiplying by F, the apparent specific activity at any weight can be converted into the standard specific activity. The novel aspect of Hendler's paper is the finding that when F is plotted against weight of sample, a straight line results.

Table 1. Slopes and intercepts of tangents to the initial and final part of the self-absorption correction curves F. The tangents were constructed by drawing a line connecting the two lowest and two highest integer values on the curve. (Thus for No. 1, 5 and 6 mg, and 21 and 22 mg.)

No.	Source	Preparation	Area (cm^2)	Range (mg)	Tangents of F			
					Initial		Final	
					Slope	Intercept	Slope	Intercept
1	J. Katz	$BaC^{14}O_3$ on filter paper	3.14	5–22	0.018	0.68	0.049	0.17
2	J. Katz	$BaC^{14}O_3$ on filter paper	2.55	6–18	0.023	0.65	0.071	0.04
3	Veterans Administration Hospital, Los Angeles, California	$BaC^{14}O_3$ on filter paper	4.50	8–38	0.016	0.58	0.035	0.30
4	Department of Physiology, Univ. of California, Berkeley	$BaC^{14}O_3$ on filter paper	19.5	10–85	0.011	0.60	0.013	0.37
5	Department of Biology, California Institute of Technology, Pasadena	C^{14} protein on steel	2.85	5–21	0.027	0.91	0.046	0.61
6	Katz and Golden [*J. Lab. Clin. Med.* 53, 658 (1959)]	$BaS^{35}O_4$ on glass filter paper	3.14	4–25	0.032	0.59	0.048	0.35

The empirical procedure described by Hendler has been in common use in many laboratories to determine self-absorption corrections for $BaC^{14}O_3$ and other C^{14} compounds, and it has also been described in detail for $BaS^{35}O_4$ [J. Katz and S. Golden, *J. Lab. Clin. Med.* **53**, 658 (1959)]. However, as far as I am aware, F has never been found to be a linear function of sample weight.

I have at hand six conversion tables (summarized in Table 1); four tables are for $BaC^{14}O_3$, one for $BaS^{35}O_4$, and one for C^{14}-protein. Two of the tables for $BaC^{14}O_3$ and the one for $BaS^{35}O_4$ were prepared by myself; the rest have been in use for many years in three other laboratories. The $BaCO_3$ and $BaSO_4$ were prepared by collecting the precipitate with suction on filter paper; the C^{14}-protein, by evaporating aliquots in planchets. The diameter of the samples ranges from 18 to 48 mm, and the weight ranges from 5 to 85 mg. For radioassay mica end-window and gas-flow Geiger tubes of several types were used, one of the tubes (the Micromil gas-flow counter) being identical with one used by Hendler.

When the values of the conversion factor for all six tables were plotted against sample weight, the resulting curves were not linear, but increased continuously in slope. The tangent to the upper portion of these curves tended to pass through the origin. While it was difficult to extrapolate to zero mass, it seemed that, at least with two curves, the curve tends to become parallel to the abscissa.

An elementary consideration of the character of self-absorption explains the nature of the curves described above. When the region of "infinite thickness" is approached the count becomes maximal and constant, and the apparent specific activity, when the weight increases, becomes simply inversely proportional to the sample weight. F then becomes directly proportional to weight. (For instance, take the count rate at infinite thickness, at 50 mg, as 500 count/min and the reference specific activity as 20 count/min per milligram. Then F at 50, 100, 200, and 400 mg would be 2, 4, 8, and 16). Obviously, then, in this region the plot of F is a linear function of weight and when extrapolated will pass through the origin.

Consider now the region of very low mass, where the apparent specific activity is almost independent of mass. In that region F will tend to become constant and the slope will be very small. F will intersect the ordinate above the origin (see Hendler). The curve between the two regions obviously will increase in slope, reaching a constant maximal value at the region of infinite thickness, and only then become linear, and when extrapolated will intersect the origin. Our experi-

mental curves, within their range, approximately show this type of change.

It is difficult to explain why Hendler got results so markedly different from the ones described here, and it seems doubtful whether his treatment is generally valid.

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7 December 1959

The experimental basis for Katz' objection to the straight line relation of F to sample thickness cited in my article [*Science* **130**, 772 (1959)] is essentially contained in six sets of data to which he refers, and which he has kindly supplied me. Two curves for $BaCO_3$ were obtained by Katz by plating on filter paper. These have increasing slopes. One for $BaCO_3$ on filter paper has been in use for many years at the department of physiology, Berkeley, California. These data appear to fit the straight line function perfectly over the whole range from 10 to 80 mg. The curve for the fourth set of data starts with increasing slope, is linear in the central portion, and ends with decreasing slope. Clearly the nature of the curve reflects the individual manner of preparing it. The fifth set of data is described by a curve having a gradually increasing slope which, for the experimental points provided, is adequately described by a straight line.

The last set of data mentioned in Katz' report is for $BaSO_4$ and is the only set published [J. Katz and S. Golden, *J. Lab. Clin. Med.* **53**, 658 (1959)]. I shall address all particular statements to these data which are reproduced in Fig. 1. Although no generality was claimed in my paper for the treatment of S^{35} data, it is gratifying to see that a straight line describes these data with an error which, at its greatest value, is only 2 percent (Table 1). Katz mentions his counting error as being 3 to 5 percent. It must be stressed that no rigid theoretical basis was claimed for the observed straight line relation, and its justification is in its empirical usefulness. In all of Katz' data there is a tendency to increasing slope. I would suggest that at the lower weights of material plated on filter paper certain additional factors which were absent in my preparations (on stainless steel planchets) came into play. First, there is a loss of back scattering. This has been cited by Katz and Golden in their article. Second, the filter paper, being porous and of generally rougher surface than metal, might tend to block radiation from thin samples intimately residing in the texture of this material. Third, it would be difficult, at best, to know if a thin layer of precipitate was completely and evenly spread on the surface of this material. All of these factors would decrease counts observed and hence increase F as the weight was decreased.

Table 1. Comparison of values of F obtained from straight line and from Katz' and Golden's determinations. Straight line equation $F = 0.04m + 0.54$ where m = weight of sample in milligrams.

Mg	Katz' and Golden's value	Value for straight line	Difference (%)*
10	0.93	0.94	1.1
11	0.965	0.98	1.6
12	1.00	1.02	2.0
13	1.04	1.06	1.9
14	1.08	1.10	1.8
15	1.12	1.14	1.8
16	1.16	1.18	1.7
17	1.20	1.22	1.7
18	1.245	1.26	1.6
19	1.29	1.30	1.6
20	1.335	1.34	0.4
21	1.38	1.38	0
22	1.425	1.42	0.4
23	1.47	1.46	0.7
24	1.52	1.50	1.3
25	1.57	1.54	1.9

* The straight line was drawn through all points down to 4 mg. Excluding the less certain values below 10 mg, as Katz and Golden suggest in their paper, would make this small difference tend to disappear.

The "elementary" consideration of the character of self-absorption offered by Katz in his fifth and sixth paragraphs is too elementary. Katz says that when the region of infinite thickness is approached, the count rate (I) becomes constant and the apparent specific activity is therefore directly proportional to weight, with zero intercept. In other words, Katz proposes that at great thicknesses, $F = \frac{R}{I_\infty} m$. He forgets that this is an approximation for $F = \frac{R}{I_\infty} m + b$, where b is small relative to $\frac{R}{I_\infty} m$. For thin samples, Katz uses $F = \frac{R}{I_\infty} m + b$, where as m approaches 0, F approaches b. Thus Katz ignores this intercept value at great thickness but then considers it again at very small thicknesses. By this technique any straight line, $y = mx + b$, would appear to have an increasing slope. For b to equal zero, I must equal I_∞. Both the exponential and hyperbolic treatments state that the true maximum count rate (I_∞) can be achieved only at infinite thickness. Although for our purposes we must accept a discrepancy less than our experimental error between observed and theoretical maximum count rate, we cannot categorically state that such a difference does not exist.

The analysis of F shown in Katz' Table 1 is not at all relevant to the point in question. F is obtained from the best straight line drawn through all of the experimental values. It is easily obtained and can be used to correct experimental data with rather good accuracy. This is true also for the data from which Katz constructed his table. The analysis in Katz' table seems to support the contention that the values at small thicknesses are subject to the errors discussed above, which tend to raise their values.

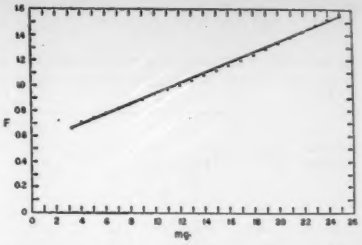

Fig. 1. F values from Katz and Golden plotted against weight of sample over a fixed area.

No rigid theoretical basis is claimed for the straight-line treatment. The obtaining of a straight line is clearly dependent upon the particular technique employed. At the National Institutes of Health, to my knowledge, six individual investigators on a variety of counters have obtained good straight-line relationships. If Katz had known that a straight line $F = 0.04m + 0.54$ could adequately describe his data, he would have saved considerable effort by using it.

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20 April 1960

Induced Somatic Mutations Affecting Erythrocyte Antigens

Abstract. The frequency of inagglutinable erythrocytes was increased in pigeons following total body irradiation and in human polycythemic patients treated with P^{32}. Persistence of the increased levels of inagglutinable cells was observed in pigeons retested at over 200 days after irradiation and in a polycythemic patient retested at 173 days posttreatment. These data provide additional evidence for the mutational origin of the antigen-lacking cells.

Atwood and Scheinberg (*1*) have proposed that the red cells which lack the A antigen are the progeny of bone-marrow stem cells in which mutations have arisen. If these inagglutinable cells arise as a result of mutation they should be increased following irradiation. The procedure for detection of the inagglu-

Table 1. Effect of irradiation on the frequency of inagglutinable cells. Dose is expressed in roentgens to the peritoneum. The inagglutinable frequencies are listed as *F* and the days following irradiation as *D*.

Subject number	Dose	Inagglutinable cell frequencies								
		Initial F	D	F	D	F	D	F	D	F
Pigeon cell carrier, x-rays										
930	0	0.0100	33	0.0090	34	0.0098				
954	500	0.1080	40	0.3370	109	0.2150	204	0.2000	432	.2411
2943	630	0.0460	51	0.3550	126	0.2520	221	0.1700		
986	745	0.0076			104	0.0360	208	0.0128		
921	818	0.0810	40	0.1250	*	*				
Human A cell carrier, x-rays										
893	832	0.0011	54	0.0021						
Human A cell carrier, γ rays from 4π cobalt source (9)										
951	101	0.0028	48	0.0026	149	0.0025				
926	500	0.0014	46	0.0180	120	0.0042	192	0.0050		
908	1004	0.0010	49	0.0030			243	0.0030†		

* Refer to text. † *P. lunatus* extract prepared at later date than extract used initially.

tinable frequency has been described by Atwood and Scheinberg (*1*).

The inagglutinable frequencies before and after irradiation are presented in Table 1. The results were obtained at various times and some represent the first retests of the inagglutinable frequency. Isotope-dilution experiments with pigeons 921, 930, 954, 986, and 2943 were carried out with pigeon cells as carrier, whereas all the other experiments were carried out with human A cells as carrier (*2*). The inagglutinable levels with pigeon cells used as carrier are higher both before and after irradiation than the levels observed with human A cells used as carrier (*3*). Bird 2943 was irradiated while it was lying on its side under the x-ray beam but all other birds given x-ray exposures were kept in a lucite cylinder which was rotated to provide uniform total body exposure (*4*). The dose in roentgens in air (in parentheses) for the various birds is as follows: 954 (700), 2943 (1000), 921 (1023), 986 (945), 893 (1040), 908 (1224), 926 (610), and 951 (120).

Bird 921 was re-bled 7 days after the first retest and showed a fourfold increase in the number of inagglutinable cells. After 61 days the frequency was indistinguishable from the pre-irradiation frequency. These observations suggested that the observed increase in inagglutinable cells was due merely to an increased frequency of young cells arising as a consequence of bleeding. Numerous experiments were carried out which demonstrate that the inagglutinable cells are not merely young cells. Bone marrow cells were found to be reactive with *Phaseolus lunatus* extract and conformed to the red-cell antigen type. Young cells are therefore reactive with *P. lunatus* extract. *Phaseolus lunatus* inagglutinable cells isolated from a population of reactive cells were found to be identical in their reactivity with the initial cell population in that both selected and unselected cells were reactive with two seed extracts and both failed to react with three other seed extracts. With respect to the isolation medium, *P. lunatus* extract, the unselected cells were reactive, whereas the selected cells did not react. Therefore, the inagglutinable (selected) cells are specifically nonreactive with *P. lunatus* extract. As can be seen from the isotope dilution experiments with bird 930 (Table 1), bleeding, by itself, does not explain the increase in the frequency of inagglutinable cells following irradiation.

Experiments were also carried out on a human A_2 polycythemic patient (AG) treated with 2 mc of P^{32} (*5*). The use of the pretreatment value is precluded by sampling error of the initial count, but the frequency of inagglutinables obtained 7 days posttreatment was .0021; 55 days later it was .016; at 97 days, .018; and at 173 days, .0155. This remarkable increase has remained fairly constant for the period of testing. Atwood and Megill (*6, 7*) have obtained results on the inagglutinable frequency in two A_1 patients given 4 mc of P^{32}. The "O" cell population which would be comparable to the inagglutinable frequency of patient AG follows. Patient GP: initially, .00074; 8 days, .00044; 28 days, .00048; 68 days, .00090; 140 days, .00315. Patient AR: initially, .00073; 16 days, .0018; 34 days, .0007; 50 days, .0013; 70 days, .0016; 170 days, .0024.

These constitute definite increases in the "O" level following irradiation, but the variation between individuals precludes a direct comparison with patient AG. However, it appears that 4 mc has not resulted in a greater "O" cell frequency than that obtained with 2 mc, analogous with the difference between the median and high doses observed with pigeons given total body irradiation where doses of 1000 r did not result in an increase in the frequency of inagglutinable cells over that of birds given 500 r. The A_2 levels that were observed by Atwood and Megill (*8*) were more erratic; this is attributed to the effect of temperature on the agglutination reaction with *Dolichos biflorus*.

There is a suggestion of selection against the cells with the inagglutinable phenotype at high levels of irradiation which is also evident in the continued decline in the frequency of inagglutinables in pigeons 954, 986, and 2943. However, at over 200 days there is still a higher frequency of inagglutinables in these pigeons than was observed prior to irradiation. The requirement for additional data on the dose-response relationship precludes further speculation regarding the significance of this observation. The possibility that heavy selection against the inagglutinable cells takes place with high doses of radiation implies gross nuclear or cytoplasmic damage as a result of the high levels of irradiation. Only those bone-marrow stem cells which suffer minor damage will continue to produce terminal red cells which are inagglutinable. It is not known whether the changes induced in the bone marrow cells affect primarily the nucleus or the cytoplasm. However, the persistence of an increased level of inagglutinable cells in irradiated pigeons and in the polycythemic patient suggests that it is the nucleus which is primarily affected.

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References and Notes

1. K. C. Atwood and S. L. Scheinberg, *J. Cellular Comp. Physiol.* **52**, Supp. 1, 97 (1958); *Science* **129**, 936 (1959).
2. Blood obtained from patient HB through courtesy of B. Gibbs, Walter Reed Army Medical Center.
3. S. L. Scheinberg and R. P. Reckel, *Genetics*, in press.
4. The x-ray machine was made available through the kindness of M. E. Jefferson, U.S. Department of Agriculture, Beltsville, Md.
5. Blood samples were made available through the kindness of Dr. Snyder, Arlington, Va.
6. K. C. Atwood and Donald Megill, "Erythrocyte automosaicism in polycythemics treated with Phosphorus-32," abstract in *Science* **130**, 1411 (1959).
7. Appreciation is expressed to K. C. Atwood, University of Chicago, for use of data presented here and for reading this manuscript.
8. The A_2 levels in patient GP: initially, .0076; 28 days, .0245; 68 days, .0160; 132 days, .0980. Patient AR: initially, .0200; 16 days, .110; 34 days, .0400; 50 days, .0140; 70 days, .0190; 170 days, .01.
9. Radiation facility was made available through the kindness of Commander Chambers, Naval Medical Institute, Bethesda, Md.

30 September 1959

Strontium-90 in Ecuador

Abstract. Samples of bone and soil collected in 1958 show highest values for Sr^{90} in the tropical region on the east side of the Andes. Lowest values are found in the high central valley, where samples used in estimating world-wide distribution of fallout were collected. If the major fallout deposition occurs in the interior of the South American continent, such estimates for these latitudes may be low by as much as a factor of ten. Although there has apparently been greater Sr^{90} deposition in regions of greater rainfall, analysis of data from 16 locations fails to show a significant correlation between rainfall and fallout.

From January through May in 1958, 45 samples of soil and bones from 19 cattle were collected along the equator in Ecuador, from the Pacific coast to the tropical regions on the eastern side of the Andes, including points up to 13,500 feet above sea level, in the mountains. These samples were analyzed for Sr^{90} content in the laboratories of the Analysis Branch, Idaho Operations Office of the U.S. Atomic Energy Commission (*1*).

Ecuador provides unusual extremes in altitude, and hence in climatic conditions, in a very short linear distance. From the coast to a distance of approximately 100 miles inland, one passes through tropical, subtropical, temperate, and páramo (tundra) zones. In a comparable distance east from the high mountains, one again descends to regions of the tropical rain forest. These climatic changes are manifestations of differences in both temperature and precipitation, and both are reflections of the topography. The mountain chain is divided roughly into two rows of high peaks with a broad temperate valley between. The climate of the valley is temperate because of its elevation, which averages about 9000 feet above sea level. It is an arid region, most of the moisture being excluded by the higher mountains to the east and west. Nearly all of the major cities, the majority of the population, and the most extensive agricultural areas are located in this valley.

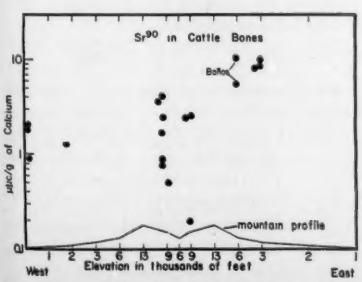

Fig. 1. Strontium-90 in cattle bones from Ecuador.

Figure 1 shows Sr^{90} content of cattle bones, expressed as micromicrocuries per gram of calcium, and plotted against location along an east-west transect across the country. The transect is indicated on the abscissa by changing elevation with distance (not to scale). A diagram of the mountain profile, according to the scale of the abscissa, has been added for aid in comparing relative positions of the sample locations. Figure 2 presents the results of soil samples, with Sr^{90} content expressed in millicuries per square mile.

The Sr^{90} levels are distinctly highest at the lower elevations to the east. Due to difficulties of transportation in the country, the cattle parts may be considered of local origin, with some possible exceptions in the highlands. Bone samples from five species of native animals, not shown in the figures, were collected in the tropics of the eastern slope. These samples and their Sr^{90} values in micromicrocuries per gram of Ca were: white-lipped peccary (*Tagassu pecari*), 3; collared peccary (*Tagassu tajacu*), 2; three-toed sloth (*Bradypus*), 10; wild dog (*Atelocynus microtus*), 5; and a deer (*Cervidae*), 2. A kinkajou (*Potos*) from 700 feet elevation near the west coast had 2 $\mu\mu c$/gm of Ca.

Soil levels of Sr^{90} were lowest along the arid strip of coast, arid because of cold oceanic currents, and the interior regions of the high central valley, also an area of little rainfall. The lowest point toward the eastern base of the mountains in Fig. 2 represents an unusually arid area for that region, the town of Baños which is hemmed in by high ridges. Two samples of cattle bones from Baños were comparatively high in Sr^{90}. This discrepancy cannot be explained by soil calcium values. Indeed, these data show no relationship between soil Ca and either soil Sr^{90} or bone Sr^{90}. If there is a correlation between Sr^{90} deposition and rainfall, then perhaps the Baños cattle are high in this isotope because they grazed in adjacent areas of greater rainfall and more lush vegetation rather than in the semiarid area around the town.

Soil levels of Sr^{90}, being higher in the humid tropical regions and at high elevations, seem to substantiate a direct correlation between fallout deposition and rainfall. Data for 16 locations from which values for both annual precipitation (average for 3 to 5 years) and Sr^{90} in soil are available (Table 1) were analyzed for linear regression. The result was not significant ($P > 0.3$), indicating that these data fail to show a correlation between rainfall and Sr^{90} in soil.

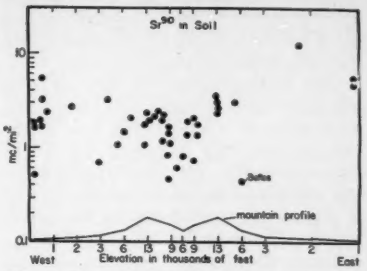

Fig. 2. Strontium-90 in soil from Ecuador.

There was some concern that soil samples taken near the end of the collecting period might be significantly higher in activity because of fresh fallout moving in at that time from the 1958 nuclear tests being conducted at the Pacific Proving Grounds. Thyroid glands of both cattle and sheep collected in Quito and analyzed for I^{131} content by L. Van Middlesworth of the University of Tennessee increased by factors of 100 or more between early and late May. Additional data timing the arrival of the fallout in the vicinity was obtained by the detection of W^{185} (*2*). Comparison of soil samples taken before and after arrival of fallout shows no greater variation than that shown by other samples not influenced by this variable.

It is important to note that the valley between the high peaks is a region of particularly low Sr^{90} deposition. Samples used for estimating world-wide distribution of fallout (*3*) have apparently been collected in such locations, because here are the population centers or commercial centers, and samples are frequently collected near

Table 1. Comparison of average annual precipitation and Sr^{90} content of soil. Linear regression analysis was not significant ($p > 0.3$).

Locality	Precipitation (mm)	Sr^{90} (mc/mi²)
Coast		
Manta	243	1.8
Esmeraldas	822	1.6
San Lorenzo	2797	1.6
Western tropical region		
Quevedo	2484	5.4
Santo Domingo	4018	2.7
Central valley		
Aloag	940	1.6
Quito	1364	1.4
Calderón	960	0.6
Guaillabamba	565	1.4
Tabacundo	876	1.7
Otovalo	1029	2.1
Ibarra	743	1.9
Latacunga	272	1.4
Ambato	472	0.7
Eastern subtropical region		
Baños	1249	0.5
Eastern tropical region		
Puyo	3871	12.6

government agencies, airports, and other facilities. Such samples may provide estimates of Sr^{90} deposition that are low by a factor of 2 to 10, compared with the deposition in adjacent areas.

The highest values for Sr^{90} in these samples consistently come from the tropical zone at the eastern base of the mountains. This suggests, since the moisture moves into that region from the east across the entire continent, that a greater portion of the fallout moves from east to west in this part of the southern hemisphere. This is consistent with general global circulation patterns for these latitudes. Perhaps the major portion of the fallout on the South American continent may be found in the interior tropical regions, although the path of circulation from the point of origin is obscure.

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References and Notes

1. Samples were collected under sponsorship of the Division of Biology and Medicine of the U.S. Atomic Energy Commission and the National Science Foundation. G. W. Prescott and R. W. Hodges aided in collection of samples. E. R. Ebersole, P. B. LeFleur, and W. C. Pierce carried out chemical analyses. The method of analysis was essentially the soil leach procedure described in *NYO-4700* (1957).
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31 March 1960

Decarboxylase Inhibition and Blood Pressure Reduction by α-Methyl-3,4-Dihydroxy-DL-phenylalanine

Abstract. α-Methyl-3,4-dihydroxy-DL-phenylalanine has been found to be an effective inhibitor of aromatic amino acid decarboxylation in man. This was shown by decreased formation of serotonin, tryptamine, and tyramine from the precursor amino acids. Reduction of amine biosynthesis is associated with lowering of blood pressure in hypertensive patients and a transient sedative effect.

The aromatic amines impinge on almost every area of biological and medical interest. Two basic approaches to the study of amine metabolism, which have had interesting and practical implications in man, are depletion of tissue stores of amines by the rauwolfia alkaloids and inhibition of the degradation of amines by monoamine oxidase inhibitors. Since decarboxylation of an amino acid is a requisite reaction in the biosynthesis of aromatic amines, decarboxylase inhibition seemed to offer a third biochemical approach in this area and one which had not been explored previously in clinical studies.

A number of compounds are known to inhibit decarboxylation in experimental animals (*1*, *2*). Of these α-methyl-3,4-dihydroxy-DL-phenylalanine (α-methyl-dopa) was selected for possible administration to humans. This compound, synthesized by Stein, Bronner, and Pfister (*3*), was first shown to be an effective inhibitor of dihydroxyphenylalanine decarboxylation in vitro by Sourkes in 1953 (*1*), an effect which was subsequently confirmed pharmacologically (*4*). Inhibition of 5-hydroxytryptophan decarboxylation was also demonstrated (*5*), and a decrease in brain serotonin levels was observed after parenteral administration of this inhibitor to mice (*6*).

Techniques for the measurement of amino acid decarboxylation in man have been developed recently in this laboratory. Preparatory to clinical investigations of α-methyl-dopa, chronic toxicity studies were performed by the Merck Sharp & Dohme Laboratories, and the compound was found to have a wide range of safety. α-Methyl-dopa was then administered to hypertensive patients at the Clinical Center. It was found to be a highly effective inhibitor of aromatic amino acid decarboxylation in man and to have hypotensive and sedative properties.

The decarboxylation of 5-hydroxytryptophan, tyrosine, and tryptophan was investigated by measuring the urinary excretion of their respective amines (serotonin, tyramine, and tryptamine) after administration of the precursor amino acid. L-Tryptophan and L-tyrosine were administered orally and 5-hydroxy-DL-tryptophan was given intravenously over a period of 90 minutes. Starting with administration of the amino acid, urines were collected for a period of 8 hours. During this time, the patients received a diet low and constant in tryptophan and tyrosine. When all control studies were completed, single 2.0-gm doses of α-methyl-dopa were administered daily. After at least 2 days of treatment with the inhibitor, the individual amino acids were administered again and urine was collected as before. In each case, the amino acid was given 2 hours after the last dose of α-methyl-dopa. Urinary serotonin was isolated from small aliquots of urine on an IRC-50 (NH_4^+) column, eluted with 1*N* HCl, and assayed fluorimetrically (*7*). Tryptamine (*8*) and tyramine (*9*) were assayed by methods developed previously in this laboratory.

Table 1. Inhibition of the decarboxylation of three amino acids by α-methyl-dopa. Values represent micrograms of amine excreted in the urine during an 8-hour period. For tyramine and tryptamine they represent the average of two experiments and for serotonin an individual experiment.

Patient	Urinary serotonin (after infusion of 30 mg of 5-hydroxy-DL-tryptophan)		Urinary tyramine (after L-tyrosine 125 mg/kg orally)		Urinary tryptamine (after L-tryptophan 50 mg/kg orally)	
	Control	α-methyl-dopa	Control	α-methyl-dopa	Control	α-methyl-dopa
V.K.			968	262	373	180
R.E.	3086	1347	1090	155	503	200
E.C.	2423	649	422	78	52	31
J.W.	2806	1086	750	124	56	30
H.F.	3570	1315				

As shown in Table 1, amine formation after administration of all three amino acids was decreased by α-methyl-dopa, the decreases averaging 63 percent for 5-hydroxytryptophan, 80 percent for tyrosine, and 50 percent for tryptophan. α-Methyl-dopa also reduced the excretion of tyramine 50 to 85 percent in comparable 8-hour periods during which loading with tyrosine was omitted. The possibility existed that the effect of α-methyl-dopa on the excretion of amines might be due to

Table 2. Reduction of blood pressure by α-methyl-dopa.

Patient	Dose (gm/day)	Average blood pressures (mm-Hg)				Change	
		Control (placebo) week		Final week of drug		Lying	Standing
		Lying	Standing	Lying	Standing		
V.K.	2.0	159/93	168/102	135/79	122/82	−24/−14	−46/−20
F.J.	1.5 –2.0	173/94	169/104	136/82	116/81	−37/−12	−53/−23
F.N.	0.75–2.0	244/140	220/146	229/147	171/117	−15/+7	−49/−29
R.E.	1.0 –2.0	140/97	142/107	119/80	120/90	−21/−17	−22/−17
H.C.	1.5 –2.5	202/128	177/130	196/127	142/113	−6/−1	−35/−17
J.M.	2.0 –4.0	208/122	191/123	212/143	144/107	+4/+21	−47/−36
E.C.	2.0 –3.0	155/98	150/104	133/79	109/78	−22/−19	−41/−26
E.B.	2.0 –3.25	208/126	196/125	227/121	170/109	+19/−5	−26/−16
H.J.	2.0 –2.5	154/114	144/111	147/110	122/89	−7/−4	−22/−22
R.P.	3.0 –6.0	227/142	220/141	200/113	170/114	−27/−29	−50/−27

alterations in amino acid transport. However, measurement of tyrosine blood levels (*10*) in two patients following tyrosine administration showed that α-methyl-dopa did not affect the absorption of tyrosine from the intestine; in all cases the values rose to more than 5 times control levels. In other studies, it was shown that α-methyl-dopa did not influence the uptake of tyrosine by brain and muscle (*11*).

The effect of α-methyl-dopa was also reflected in a lowered excretion of 5-hydroxyindoleacetic acid and indoleacetic acid after the 5-hydroxytryptophan and tryptophan loads. The inhibitor did not influence the renal clearance of these acids. To ascertain further the effect of α-methyl-dopa on 5-hyroxytryptophan decarboxylation, the inhibitor was administered to two patients with metastatic carcinoid. A greater than fivefold increase in urinary 5-hydroxytryptophan and a decrease in urinary 5-hydroxyindoleacetic acid were observed in both cases (*12*).

Since the initial studies were carried out on hypertensive patients whose blood pressures were regularly measured, it became immediately apparent that α-methyl-dopa was a hypotensive agent. Accordingly, the blood pressure effects of α-methyl-dopa were investigated in ten hospitalized patients with primary hypertension. The lying and standing blood pressures were recorded four times daily. Placebo medication was given in pre- or posttreatment control periods, or both. α-Methyl-dopa was administered orally for periods of 7 to 28 days, initially as a single daily dose but later in divided doses at 8-hour intervals.

A summary of the blood pressure alterations produced by α-methyl-dopa is presented in Table 2. Appreciable reduction of the standing blood pressure occurred in all cases. In addition, a lowering of recumbent pressures was observed in five of the patients. In two patients (F. J. and F. N.), the postural hypotension was of such a magnitude as to necessitate reduction of dosage. For a period of 24 to 72 hours after initiating α-methyl-dopa, or after increasing its dosage, all patients had a temporary change in mental status, apparent to observers and manifested as sedation, tranquility, or fatigue. These obvious central effects seemed limited to the first 72 hours but further evaluation is required to determine whether more subtle effects may persist beyond that period.

These studies demonstrate unequivocally that aromatic amino acid decarboxylation can be inhibited in man by α-methyl-dopa, and indicate once more a relationship between amine metabolism and blood pressure regulation. The sedative effects of the drug are also in line with current thoughts concerning the role of amines in brain function. The effect of α-methyl-dopa on blood pressure has been of a sufficient magnitude to warrant extensive therapeutic evaluation of this compound and related aromatic amino acid decarboxylase inhibitors in hypertension. In fact, therapeutic trials in all disorders characterized by a relative or absolute excess of aromatic amines are indicated (*13*).

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11. We are greatly indebted to Dr. Gordon Guroff for carrying out these experiments.
12. A description of details of the latter studies is in preparation.
13. The technical assistance of Mrs. Consuelo Mullenberg is gratefully acknowledged. The Merck Sharp & Dohme Reseach Laboratories generously supplied the α-methyl-dopa (MK-350) for these studies.

7 March 1960

Behavior in the Cold after Acclimatization

Abstract. Experimentally naive albino rats begin to press a lever for short bursts of radiant heat earlier in a 16-hour session at 2°C than rats that have been living at this temperature for about a month. This difference reflects the different rates at which body temperature in the cold falls in acclimatized and nonacclimatized animals.

If a rat's fur is clipped, and the rat is then put into a cold environment (2°C), it will almost always die within 24 hours. If, however, it has lived in the cold for at least a month before being clipped, it will probably survive (*1*). Adaptation of this kind is called acclimatization. The present experiment examines the way this physiological acclimatization is accompanied by changes in thermoregulatory behavior (*2*).

Sixteen male albino rats from Sprague-Dawley stock, about 100 days old, were each given one 16-hour trial in a heat reinforcement chamber (*3*) located in a room maintained at 2° ± 1°C. While in this chamber, the rat, by pressing a plastic lever, could get 2-second bursts of radiant heat from a 250-watt infrared lamp (red bulb) located 10 inches above the floor of the chamber. Each press of the lever gave it one such burst; presses made while the lamp was on had no effect. The animals had received no previous experimental experience.

Eight of the 16 rats (randomly chosen) lived at 2°C for from 30 to 41 days before their experimental sessions. The other eight lived at 25°C. All were housed two or three to a cage and had free access to food (Purina Lab Chow) and water. Eight hours before an animal from the acclimatized group started an experimental session it was removed from the cold room to a cage near the control animals. This was done to make conditions immediately prior to the session comparable for the two groups (*4*). The rats were clipped completely with an electric clipper about 30 minutes before a session began.

During the first half-hour in the chamber the rats obtained between 4 and 25 reinforcements; the means for the control and acclimatized groups (13.0 and 16.8, respectively) did not differ significantly ($p > .30$). Almost all of these reinforcements occurred in the first few minutes. From then on most rats responded only occasionally until they made an abrupt transition to a steady rate. These data on early responding make it unlikely that differences in the time required to achieve a steady rate were due to differences in activity.

Acclimatized rats generally waited longer than control rats before starting to work at a steady rate for heat. The individual curves in Fig. 1 are ranked in terms of these latencies. The difference in latency is significant at the .01 level by a Wilcoxon unpaired replicates test (*5*).

All eight of the normal rats, but only five of the acclimatized rats, had been responding steadily for at least an hour by the end of the 16-hour session. The mean rates for these two groups were 5.6 reinforcements per minute (S.E. = .24) for the acclimatized rats, and 6.3 reinforcements per minute (S.E. = .52) for the control rats. This difference is not significant ($p > .20$).

Carlton and Marks reported that rats exposed to cold for 10 days turn on a heating device more frequently than rats living at room temperature (*6*). As they themselves have noted, this behavior was probably due to the fact that acclimatization was so incomplete at 10 days that rats were still losing weight at that time (*7*), and weight loss

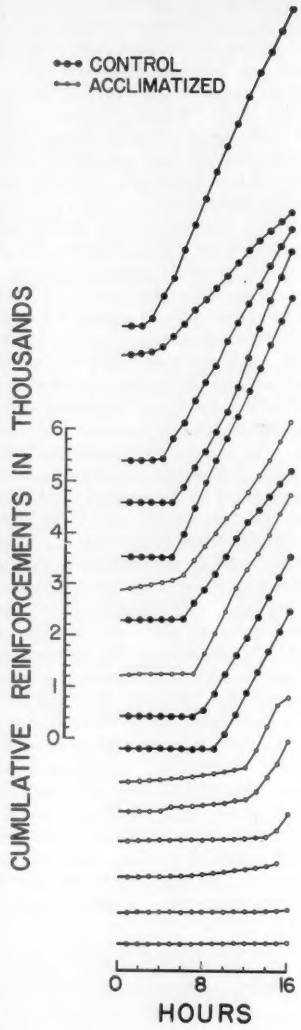
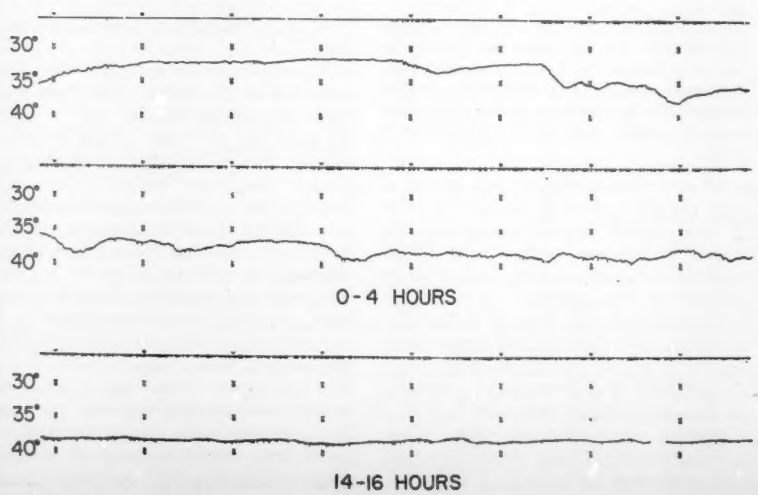


Fig. 1. (Left) Cumulative heat reinforcements received by acclimatized and control albino rats at 2°C. Each reinforcement was a burst of radiant heat 2 seconds long. The curves are in rank order with respect to the time that elapsed before a steady rate was attained. An equipment failure led to the loss of the last hour of data for the animal whose curve is third from the bottom. Fig. 2. (Below) Body temperature variations of one rat. The two tracings in the top section represent hours 0 to 2 and 2 to 4. The bottom tracing corresponds to the last 2 hours of the session. The line above each temperature tracing was made by an event pen. Each reinforcement caused it to deflect momentarily so that the density of the deflections reflects the reinforcement rate.



itself leads to higher rates of responding for heat (*8*). In the present experiment the acclimatized rats showed a significant increase in latency and an insignificant decrease in rate despite the fact that they averaged 35 grams less than the controls.

The most likely physiological basis for the difference in latency is a difference between the two groups in how quickly body temperature falls. Others have shown that during exposure to cold acclimatized rats maintain a constant body temperature much longer than nonacclimatized rats (*9*).

Evidence that body temperature and working for heat in the cold are related has been obtained by observing the subcutaneous temperature of eight other rats working for heat. Figure 2 shows the first four and last two hours from a typical record. A plastic tube was inserted under the skin of the back and tied to the supraspinous ligament. The wound was allowed several days to heal. The animal was then shaved and put into the heat reinforcement chamber for the first time, with a thermocouple inserted into the tube. There was little responding at first, only 34 reinforcements being obtained in the first 85 minutes. The rat's temperature declined from 36° to 32.5°C. It then started to respond regularly and got 5634 reinforcements during the rest of the 16-hour session, keeping its subcutaneous temperature between 35.0° and 39.5°C during this time. During the last 2 hours the temperature remained between 37.8° and 39.0°C. This is a direct demonstration of how rats adjust their behavior to maintain a fairly constant peripheral temperature.

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B-18

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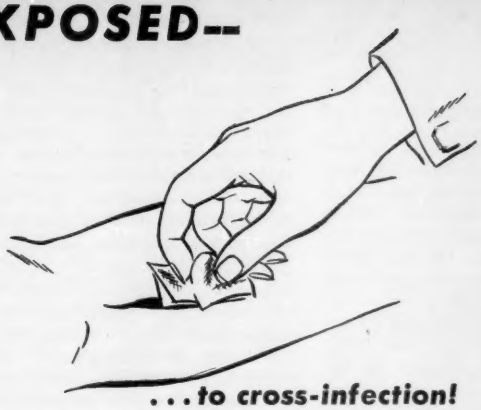
27 April 1960

EXPOSED--



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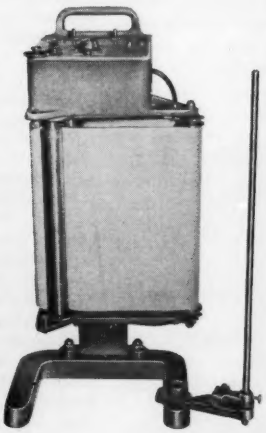

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This union, with headquarters in Paris, now comprises 16 international organizations. Several of these were in existence before UNESCO itself was organized, and most of them have spread their activities over several continents, thereby aiding UNESCO in its task of assisting the economically underdeveloped parts of the world. The member organizations seek to promote the development of engineering and other applied sciences by means of international meetings, publications, preparation of multilingual vocabularies and bibliographical bulletins, and exchanges of persons between countries.

The union enjoys the advantages of the status of a consultant for UNESCO and of enrollment on the register of the U.N. Secretary-General. It brings the support of its member organizations to bear upon all those lines of research which UNESCO is promoting through the existing international advisory committees for the arid zone, the humid tropical zone, and the marine sciences, respectively. Further, the union is permanently represented on the International Advisory Committee for Research in the Natural Sciences Program of UNESCO.

The union, as such, takes no technical part in researches which are the concern of its member organizations, but it helps them to organize their congresses and symposia, and to publish the reports and proceedings of those meetings.

The union has endeavored to guide the activities of its members through two special means—publication of multilingual vocabularies and bibliographical documentation—observing in these matters the directives of UNESCO's Department of Natural Sciences.

The Union of International Engineering Organizations is continually undergoing expansion and welcomes application for membership from qualified organizations. An organization which wishes to join the union must fulfill the following conditions: (i) it must be concerned with international collaboration within the field of the engineering sciences; (ii) its objectives as disclosed by its constitution, must cover a clearly defined part of that field; (iii) it must have, in at least ten countries not situated in the same geographical region, national committees or a substantial number of members; (iv) its governing body must have an international composition, without geographical limitation; and (v) it must be a nongovernmental organization.

Further information may be obtained from: Union des Associations Techniques Internationales, 62, rue de Courcelles, Paris 8°, France.

B. DE COMMINGES
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Forthcoming Events

July

18–22. Peaceful Application of Nuclear Energy, 3rd Inter-American symp., Petropolis, Rio de Janeiro, Brazil. (J. D. Perkinson, Jr., Inter-American Nuclear Energy Commission, c/o Pan American Union, Washington 6)

18–23. Endocrinology, 1st intern. cong., Copenhagen, Denmark. (G. Pincus, 1st Intern. Cong. of Endocrinology, Worcester Foundation, Shrewsbury, Mass.)

18–25. French Assoc. for the Advancement of Science, 79th cong., Grenoble. (Association Française pour l'Avancement des Sciences, 28 rue Serpente, Paris 6°)

19–22. International Conf. on Scientific Problems of Crop Protection, Budapest, Hungary. (Z. Király, Research Inst. for Plant Protection, Budapest)

21–27. Medical Electronics, 3rd intern. conf., Olympia, London, England. (Secretary, Institution of Electrical Engineers, Savoy Pl., London, W.C.2)

23–28. Otolaryngology, 7th intern. cong., Paris, France. (H. Guillon, 6, avenue MacMahon, Paris, 17°)

24–19. Modern Physical Theories and Associated Mathematical Developments. Boulder, Colo. (K. O. Friedricks, New York Univ., 25 Waverly Pl., New York)

25–6. International Assoc. of Physical Oceanography, 13th general assembly, Helsinki, Finland. (B. Kullenberg, c/o Oceanografiska Institutet, P.O. Box 1038, Goteborg 4, Sweden)

26–28. Poliomyelitis, 5th intern, conf., Copenhagen, Denmark. (S. E. Henwood, International Poliomyelitis Congress, 120 Broadway, New York 5)

27–12. Mathematical Statistics and Probability, symp., Berkeley, Calif. (A. P. Burroughs, Air Force Office of Scientific Research, Research Information Office, AFOSR/USAF, Washington 25)

28–29. Computers and Data Processing, 7th annual symp., Estes Park, Colo. (W.

H. Eichelberger, Denver Research Inst. Univ. of Denver, Denver 10, Colo.)

30–6. Institute on Religion in an Age of Science, 7th annual conf., Star Island, N.H. (R. Burhoe, American Acad. of Arts and Sciences, 280 Newton St., Brookline 46, Mass.)

31–5. Alcohol and Alcoholism, 26th intern. cong., Stockholm, Sweden. (A. Tongue, Bureau International contre l'Alcoolisme, Case Gare 49, Lausanne, Switzerland)

31–5. Photobiology, 3rd intern. cong., Copenhagen, Denmark. (A. Hollaender, Biology Div., Oak Ridge Natl. Laboratory, Oak Ridge, Tenn.)

31–6. Psychology, 16th intern. cong., Cologne, Germany. (Prof. Undeutsch, Psychology Inst. Universität, Cologne)

31–7. Anthropological and Ethnological Sciences, 6th intern. cong., Paris, France. (H. Vallis, Directeur, Musée de l'Homme, Palais de Chaillot, Place du Trocadéro, Paris 16°)

August

1–3. Global Communications, 4th symp., Washington, D.C. (R. L. Clark, c/o Office of Director of Defense Research and Engineering, Washington 25)

1–6. Esperanto Cong., 45 annual intern., Brussels, Belgium. (45-a Universala Kongreso de Esperanto, Brussels)

1–12. Modulation Theory and Systems, Cambridge, Mass. (E. J. Baghdady, Dept. of Electrical Engineering, Massachusetts Inst. of Technology, Cambridge)

2–5. Poultry Science Assoc., Davis, Calif. (C. B. Ryan, PSA, Dept. of Poultry Husbandry, Texas A & M College, College Station)

3–6. Gas Chromatography (Infrared Spectroscopy Inst.), Nashville, Tenn. (N. Fuson, Fisk Infrared Inst., Fisk Univ., Nashville 8)

3–6. Rarefied Gas Dynamics, 2nd intern. symp. (by invitation only), Berkeley, Calif. (Engineering and Science Extension, Univ. of California, 2451 Bancroft Way, Berkeley 4)

6–12. International Geographical Cong., 19th, Stockholm, Sweden. (IGC, Postfach, Stockholm 6)

7–10. American Soc. of Clinical Hypnosis, Miami, Fla. (S. Hershman, 6770 N. Lincoln Ave., Chicago 46, Ill.)

7–12. Gerontology, 5th intern. cong., San Francisco, Calif. (L. Kuplan, Intern. Cong. of Gerontology, P.O. Box 2103, Sacramento 10, Calif.)

7–13. Industrial Research Conf., Harriman, N.Y. (Miss M. F. Garvey, Industrial and Management Engineering Dept., Columbia Univ., New York 27)

8–11. American Astronautical Soc., Seattle, Wash. (R. M. Bridgforth, AAS, Propulsion Unit, Boeing Airplane Co., Aero-Space Div., P.O. Box 3707, Seattle)

8–12. American Inst. of Electrical Engineers, San Diego, Calif. (R. S. Gardner, AIEE, 33 W. 39 St., New York 18)

8–13. World Federation for Mental Health, 13th annual, Edinburgh, Scotland. (Secretariat, WFMH, 19 Manchester St., London, W.1, England)

8–20. American Soc. of Criminology, London, England. (D. E. J. MacNamara, New York Inst. of Criminology, 115–117 W. 42 St., New York 36)

9–13. Hail Storms, intern conf., Verona, Italy. (H. G. M. Ligpa, American Meteorological Soc., Stanford Research Inst., Stanford, Calif.)

11–13. Rocky Mountain Radiological Soc., Denver, Colo. (J. H. Freed, 4200 E. Ninth Ave., Denver 20)

11–16. Canadian Teachers Federation, Winnipeg, Manitoba. (G. G. Croskery, 444 MacLaren St., Ottawa 4, Ontario)

14–19. American Pharmaceutical Assoc., Washington, D.C. (R. P. Fischelis, APA, 2215 Constitution Ave., NW, Washington 7)

14–19. International Cong. of Clinical Chemistry, Edinburgh, Scotland. (S. C. Frazer, Clinical Laboratory, Royal Infirmary, Edinburgh)

14–20. Cardiology, 6th Inter-American cong., Rio de Janeiro, Brazil. (H. Alqueres, P.O. Box 1594, Rio de Janeiro)

15–16. National Assoc. of Boards of Pharmacy, Washington, D.C. (P. H. Costello, 77 W. Washington St., Chicago, Ill.)

15–17. Heat Transfer Conf., ASME and AICE, Buffalo, N.Y. (A. B. Conlin, Jr., ASME, 29 W. 39 St., New York 18)

15–17. Organic Scintillation Detectors, intern. conf., Albuquerque, N.M. (G. H. Daub, Chemistry Dept., Univ. of New Mexico, Albuquerque)

15–18. American Veterinary Medicine Assoc., Denver, Colo. (H. E. Kingman, Jr., 600 S. Michigan Ave., Chicago 5, Ill.)

(See issue of 17 June for comprehensive list)

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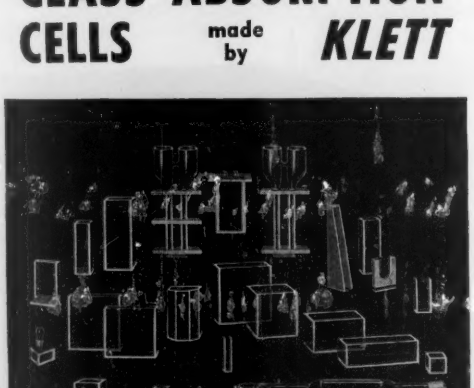

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Letters

(Continued from page 1858)

specific activity is blood-group activity. I hope that this will make clear that the use of this technique does not assume that blood-group activity should be associated with any sugars other than those found in human blood-group mucoids; as Springer points out, this assumption would be entirely unjustifiable.

The leaching process in soil is significant in that the blood-group substance remaining for analysis in buried bodies may only be the alcohol-soluble fraction. This elementary but important point is often ignored in the published techniques. While I am in complete agreement with the points made by Springer, I should like to draw attention to the absence of evidence on *rates* of decay of the blood-group substances in bodies buried under varying conditions and for varying periods.

MADELEINE SMITH
Serological Laboratory, British Museum (Natural History), London

The Makara in Ceylon

In your issue of 22 April [*Science* **131**, 1176 (1960)], Millard B. Rogers, in the article "An archeological pilgrimage to Santiago de Compostela," states that "the *makara* occurs in the earliest monumental sculptures of India, as early as the 3rd century B.C."

Makara scrolls are well known in the ancient ruined cities of Ceylon, chiefly Anuradhapura and Polonnaruwa, where these scrolls generally occur as the rails of the balustrades beside entrance steps to what little is left of the ancient buildings. The buildings, and hence the *makara* scrolls, can seldom be precisely dated, however. Anuradhapura was the capital of Ceylon from the 5th century B.C. to the 9th century A.D., but it is likely that its great period of sculpture began when Mahinda, son of the Indian emperor Asoka, brought the Buddhist doctrines to Ceylon about the middle of the 3rd century B.C. Polonnaruwa, which with considerable fresh Indian influence continued the Anuradhapura traditions of sculpture, was the medieval capital of Ceylon.

N. A. FORDE
1115 Stanwood Street, Philadelphia, Pennsylvania

N. A. Forde's letter to the editor concerning my article is a bit ambiguous, for it neither disproves my hypothesis nor supports it. For those concerned with Far Eastern archeology it simply repeats what we already know. There is one point, however, that should be clarified. Forde's implication that traditional dates concerning religious sites should be applied to artifacts found at the sites without supporting evidence is most unsound, and I feel that I should reply to this point.

It is true that the *makara* occurs in Ceylon and in all other countries where Buddhism and Hinduism were introduced. There is, so far as I know, no evidence that any existing sculptures in Ceylon can be assigned with certainty to Asokan times, and the earliest Sinhalese *makara* is one reproduced by D. T. Devendra [*Classical Sinhalese Sculpture* (London, 1958), Fig. 42]. There is a rich literature on Sinhalese archeology, of which the *Annual Reports of the Archaeological Survey of Ceylon* (1884 to date) form the core.

Since the tradition of the *makara* in literature predates the earliest known *makara* by several centuries, I would not be surprised if one day pre-Buddhistic *makara* were identified in India. It is less likely that any very early *makara* will ever be discovered in Ceylon.

MILLARD B. ROGERS
Seattle Art Museum, Seattle, Washington

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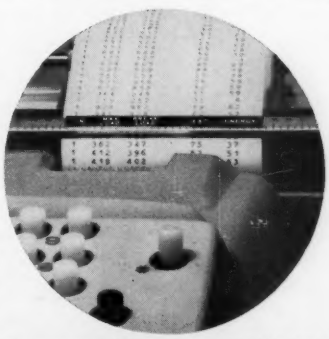

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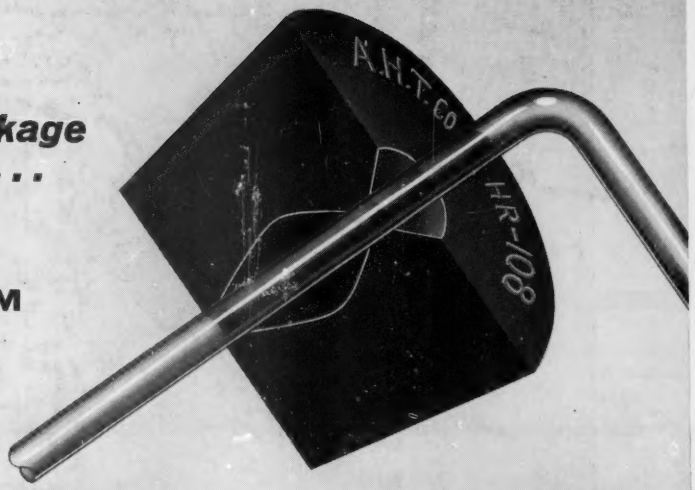

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